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Aggregate Resources Inventory Paper 66

AGGREGATE RESOURCES INVENTORY OF
TOWNSHIP OF NORWICH
Oxford County
SOUTHERN ONTARIO

by
Staff of the Engineering and Terrain Geology Section
Ontario Geological Survey

1982

Ontario
Ministry of
Natural
Resources

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Minister

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Deputy Minister

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Every possible effort is made to insure the accuracy of the information contained in this report, but the Ministry of Natural Resources does not assume any liability for errors that may occur. Source references are included in the report and users may wish to verify critical information.

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ABSTRACT

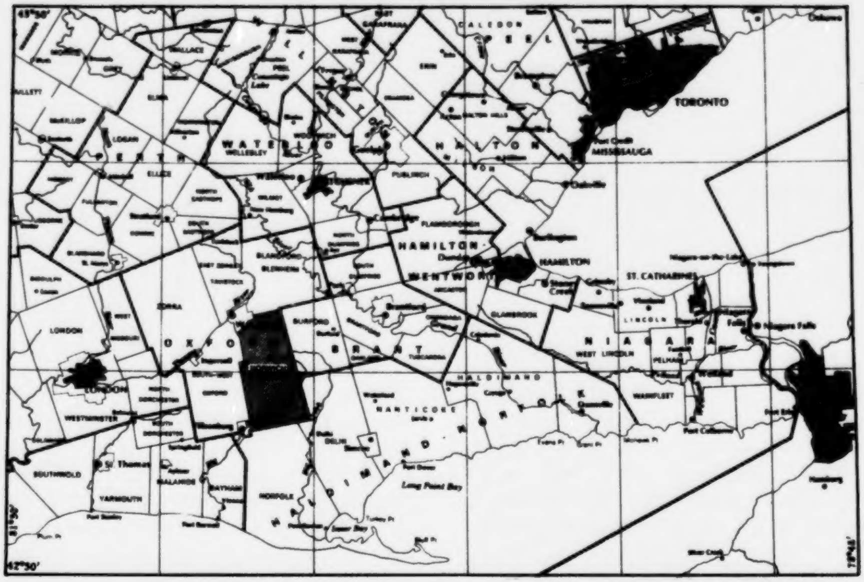

Figure I - Key Map Showing Location of the Township of Norwich, Scale 1:1 800 000.

This report includes both an inventory and evaluation of sand and gravel as well as bedrock resources in the Township of Norwich. The report is part of the Aggregate Resources Inventory Program for townships and municipalities designated under The Pits and Quarries Control Act, 1971.

In the Township of Norwich, three areas containing significant amounts of sand and gravel have been selected for possible resource protection. Selected Sand and Gravel Resource Areas occupy 500 acres (202 ha), exclusive of licenced areas. An estimated 345 acres (140 ha) are currently available for extraction, containing resources of approximately 21 million tons (19 million tonnes). The parts of the Selected Areas which are available for extraction represent 1 percent of the total area occupied by sand and gravel deposits in the township and 2 percent of the total resource tonnage.

Selected Sand and Gravel Resource Area 1 is an ice-contact deposit located southwest of Holbrook. The Area forms the most important natural aggregate deposit in the township and contains an estimated 7 million tons (6 million tonnes) of sand and gravel.

Selected Sand and Gravel Resource Area 2 is an ice-contact deposit located near the eastern boundary of the township. The Area contains possible sand and gravel resources of 6 million tons (5 million tonnes).

Selected Sand and Gravel Resource Area 3 is part of an outwash plain deposit that extends west into the Township of Southwest Oxford. Area 3 has available resources of 8 million tons (7 million tonnes).

Generally, the township has sand and gravel resources which should be able to supply local needs for a considerable period of time. However, possible resources of crushable gravel are considered low. Care should be taken to ensure the continuing availability of as much of these resources as possible.

Bedrock underlying the Township of Norwich consists of the Salina, Bass Islands, Bois Blanc, Amhertsburg, Lucas and Dundee Formations. No areas have been selected for possible resource protection, because of the great thickness of glacial sediments which overlie the bedrock surface.

Selected Resource Areas are not intended to be permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major resource is known to exist. Such Resource Areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

AGGREGATE RESOURCES INVENTORY
OF
TOWNSHIP OF NORWICH[1]

BY
STAFF OF THE ENGINEERING
AND TERRAIN GEOLOGY SECTION

INTRODUCTION

Mineral aggregates, which include bedrock-derived crushed stone as well as naturally formed sand and gravel, constitute the major raw material in Ontario's road-building and construction industries. Very large amounts of these materials are used each year throughout the Province. For example, in 1979, the total tonnage of mineral aggregates extracted was 144 million tons (131 million tonnes), greater than that of any other metallic or nonmetallic commodity mined in the Province (Ontario Ministry of Natural Resources 1980).

Although mineral aggregate deposits are plentiful in southern Ontario, they are fixed-location, nonrenewable resources which can be exploited only in those areas where they occur. Mineral aggregates are characterized by their high bulk and low unit value so that the economic value of a deposit is a function of its proximity to a market area as well as its quality and size. The potential for extractive development is usually greatest in urban fringe areas where land use competition is extreme. For these reasons the availability of adequate resources for future development is now being threatened in some areas.

Comprehensive planning and resource management strategies are required to make the best use of available resources, especially in those areas experiencing rapid development. Such strategies must be based on a sound knowledge of the total mineral aggregate resource base at both local and regional levels. The purpose of the Aggregate Resources Inventory is to provide the basic geological information required to include potential mineral aggregate resource areas in planning strategies and official plans. The reports should form the basis for discussion on those areas best suited for possible extraction. The aim is to assist decision-makers in protecting the public well-being by ensuring that adequate resources of mineral aggregate remain available for future use.

This report is a technical background document, based for the most part on geological information and interpretation. It has been designed as a component of the total planning process and should be used in conjunction with other planning considerations, to ensure the best use of a municipality's resources.

The report includes an assessment of sand, gravel and crushed bedrock. The most recent information available has been used to prepare the reports. As new information becomes available, revisions may be necessary.

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[1] Manuscript accepted for publication by Chief, Engineering and Terrain Geology Section, November 5, 1981.

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PART I - INVENTORY METHODS

FIELD AND OFFICE METHODS

The methods used to prepare the report primarily involve the interpretation of published geological data such as bedrock and surficial geology maps and reports (see References). Field methods included the examination of natural and man-made exposures of granular material. Most observations were made at quarries and sand and gravel pits located from records held by the Ontario Ministry of Transportation and Communications, the Ontario Geological Survey, and by Regional and District Offices of the Ontario Ministry of Natural Resources. Observations made at pit sites included estimates of the total face height and the proportion of gravel- and sand-sized fragments in the deposit. Observations were also made of the shape and lithology of the particles. These characteristics are important in estimating the quality and quantity of the aggregate. In areas of limited exposure, test pitting, soil probing and hand-augering techniques were used to assess subsurface materials. Airphotos at various scales were used to determine the continuity of deposits, especially in areas of limited subsurface information.

Deposits with potential for further extractive development or those where existing data are scarce, were studied in greater detail. Representative layers in these deposits were sampled in 25- to 100-pound (11 to 45 kg) units either from existing pit faces or from test pits dug by backhoe. The samples were analysed for grain size distribution and in some cases for petrographic assemblage. Analyses were performed by the laboratories of the Soils and Aggregates Section, Engineering Materials Office, Ontario Ministry of Transportation and Communications. In areas of limited subsurface exposure, drilling using a powered hollow stem auger was undertaken. The stratigraphic sections in these test holes are described in drill logs included in the report as Table 7. In some cases samples taken during the course of the drilling were analysed to determine grain size distribution. The symbols for and locations of test hole sites are noted on Map 1.

In the office, the pit and field sample data were supplemented by information on file with the Soils and Aggregates Section of the Ontario Ministry of Transportation and Communications. Data contained in these files include field estimates of the depth, composition and "workability" of deposits as well as laboratory analyses of the physical properties and chemical suitability of the aggregate. Information concerning the development history of the pits and acceptable uses of the aggregate is also recorded. The location, size, and depth of extraction of pits licenced under The Pits and Quarries Control Act, 1971 were obtained from records held by Regional and District Offices of the Ontario Ministry of Natural Resources. The cooperation of the above named groups in the compilation of inventory data is gratefully acknowledged.

Water well records, held by the Ontario Ministry of the Environment, were used in some areas to corroborate thickness estimates, or to indicate the presence of buried granular material. These records were used only in conjunction with other evidence. Soil reports published by the Ontario Ministry of Agriculture and Food were also consulted in order to supply additional information in areas with limited data. Topographic maps of the National Topographic System, at a scale of 1:50 000, were used as a compilation base for the field and office data. The information was then transferred to a township base map, also at a scale of 1:50 000, prepared by the Cartography Section of the Lands and Waters Group, Ontario Ministry of Natural Resources, for presentation in the report.

RESOURCE TONNAGE CALCULATION TECHNIQUES

SAND AND GRAVEL RESOURCES

Once the interpretative boundaries of the aggregate units have been drawn, quantitative estimates of the possible resources available can be made. Generally, the volume of a deposit can be calculated if its areal extent and average thickness are known or can be estimated. The computation methods used are as follows. First, the area of the deposit, as outlined on the final base map, is calculated in acres. The thickness values used are an approximation of the deposit thickness, based on the face heights of pits developed in the deposit or on subsurface data such as test holes and water well logs. Original tonnage values can then be calculated by multiplying the volume of the deposit by 2500 (the density factor). This factor is approximately the number of tons in a one-foot (0.3 m) thick layer of sand and gravel, one acre (0.4 ha) in extent, assuming an average density of 110 pounds per cubic foot (1766 kg per cubic metre).

Tonnage = Area x Thickness x Density Factor

Tonnage calculated in this manner must be considered only as an estimate. Furthermore, such tonnages represent amounts that existed prior to any extraction of material (i.e. original tonnage) (Table 1, Column 4).

The Selected Sand and Gravel Resource Areas in Table 3 represent only those parts of the deposit lying outside licenced areas (Column 2). Two successive subtractions are made from the unlicenced area. Column 3 accounts for the number of acres unavailable due to the presence of permanent cultural features and their associated setback requirements. Column 4 accounts for those areas lying outside of licenced properties that have previously been extracted (e.g. wayside pits are included in this category). The remaining figure is the area of the deposit currently available for extraction (Column 5). The available area is then multiplied by the estimated deposit thickness and the density factor (Column 5 x Column 6 x 2500) to give an estimate of the sand and gravel tonnage (Column 7) presently available for extractive development and/or resource protection.

BEDROCK RESOURCES

The method used to calculate resources of bedrock-derived aggregate is much the same as that described above. The areal extent of favorable bedrock formations overlain by less than 50 feet (15 m) of unconsolidated overburden is determined from bedrock geology maps, drift thickness and bedrock topography maps and from the interpretation of water well records. The measured extent of such areas is then multiplied by the estimated workable thickness of the formation, based on stratigraphic analyses and on estimates of existing quarry faces in the unit. In some cases a standardized estimate of a workable thickness of 60 feet (18 m) is used. Volume estimates are then multiplied by 3600 (the estimated weight in tons of a one-foot (0.3 m) thick section of dolostone, one acre (0.4 ha) in extent, assuming a bulk density of 165 pounds per cubic foot (2649 kg per cubic metre)).

Resources of sandstone are calculated using a bulk density estimate of 146 pounds per cubic foot (2344 kg per cubic metre) or approximately 3200 tons per acre (7173 tonnes per hectare). Shale resources are calculated on the basis of a bulk density estimate of 150 pounds per cubic foot (2408 kg per cubic metre).

UNITS AND DEFINITIONS

Although most of the measurements and other primary data available for resource tonnage calculations are given in Imperial units, Metric units have also been given in the text and on the tables which accompany the report. The Metric equivalent of the data is shown in brackets after or directly below the corresponding Imperial figures. Data are generally rounded off in accordance with the Ontario Metric Practice Guide (Metric Committee 1975).

The tonnage estimates made for sand and gravel as well as bedrock-derived aggregates are termed possible resources in accordance with terminology of the Ontario Resource Classification Scheme (Robertson 1975, p. 7) and with the Association of Professional Engineers of Ontario (1976) (see Glossary, Appendix B).

PART II - DATA PRESENTATION AND INTERPRETATION

Three maps, each portraying a different aspect of the aggregate resources in the municipality, accompany the report. Map 1, "Distribution of Sand and Gravel Deposits", gives a comprehensive inventory of the sand and gravel resources in the report area. Map 2, "Selected Sand and Gravel Resource Areas", shows those deposits which are considered to represent the largest and/or highest quality resources in the area. Map 3, "Bedrock Resources", shows the distribution of bedrock formations, the thickness of overlying unconsolidated sediments, and identifies the Selected Bedrock Resource Areas.

MAP 1: DISTRIBUTION OF SAND AND GRAVEL DEPOSITS

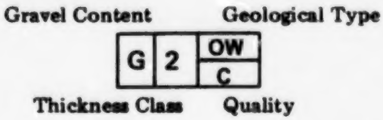
Map 1 is derived directly from the existing surficial geology maps of the area or from airphoto and field interpretation where surficial mapping is incomplete. It shows the extent and quality of sand and gravel deposits within the study area and the present level of extractive activity.

The present level of extractive activity in the study area is indicated as follows. Those areas which are licenced for extraction under The Pits and Quarries Control Act, 1971 are shown by a solid outline and identified by a number which refers to the pit descriptions in Table 2. Each description notes the owner, location and licenced acreage of the pit, as well as the estimated face height and percentage gravel. A number of unlicenced pits (abandoned pits or wayside pits operating on demand under authority of a permit) are also identified and numbered on Map 1 and described in Table 2.

Map 1 also presents a summary of available information related to the quality of aggregate contained in all the known aggregate deposits in the study area. Much of this information is contained in the symbols which are found on the map. The Deposit Symbol appears for each mapped deposit and summarizes important genetic and textural data. The Texture Symbol is a circular proportional diagram which displays the grain size distribution of the aggregate in areas where bulk samples were taken.

DEPOSIT SYMBOL

The Deposit Symbol is similar to those used in soil mapping and land classification systems commonly in use in North America. The components of the symbol indicate the gravel content, thickness of material, origin (type), and quality limitations for a given deposit. These components are illustrated by the following example:



This symbol identifies an outwash deposit 10 to 20 feet (3 to 6 m) thick containing more than 35 percent gravel. Excess silt and clay may limit uses of the aggregate in the deposit.

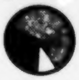
The "gravel content" and "thickness class" are basic criteria for distinguishing different deposits. The "gravel content" symbol is an upper case "S" or "G". The "S" indicates that the deposit is generally "sandy" and that gravel-sized aggregate (greater than 4.75 mm) makes up less than 35 percent of the whole deposit. "G" indicates that the aggregate probably contains more than 35 percent gravel.

The "thickness class" indicates a depth range which is related to the potential resource tonnage for each deposit. Four thickness class divisions have been established as shown in the legend for Map 1.

Two smaller sets of letters, divided from each other by a horizontal line, follow the thickness class number. The upper series of letters identify the geologic deposit type (the types are summarized with respect to their main geologic and extractive characteristics in Appendix C) and the lower series of letters identify the main quality limitations that may be present in the deposit, as discussed in the next section.

TEXTURE SYMBOL

The Texture Symbol provides a more detailed assessment of the grain size distribution in deposits where samples were taken for analysis during field study. The data from which these symbols are derived has been plotted on grain size distribution graphs. The relative amounts of gravel, sand, silt, and clay in the sampled material are shown graphically by the subdivision of a circle into proportional segments. The following example shows a hypothetical sample consisting of 30 percent gravel, 60 percent sand, and 10 percent silt and clay:



Test hole locations are shown on Map 1 by a solid drill hole symbol.

MAP 2: SELECTED SAND AND GRAVEL RESOURCE AREAS

Map 2 is an interpretative map derived from an evaluation of the deposits shown on Map 1. The deposits identified on Map 2 are those which are considered to be important in ensuring an adequate resource base for the future.

All the selected sand and gravel resource areas are first delineated by geological boundaries and then classified into three levels of significance: primary; secondary; and tertiary. These areas are identified on Map 2 by different shading patterns. Each area of primary significance is assessed as to its probable relative value as a resource in the municipality and is given a deposit number which denotes its ranking order. All such deposits are shown by a dark shading on Map 2.

Selected Sand and Gravel Resource Areas of primary significance are not permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major resource is known to exist. Such Resource Areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

Deposits of secondary significance are not ranked numerically in this report, but are indicated by a light shading on Map 2. Such deposits are believed to contain significant amounts of sand and gravel. Although deposits of secondary significance are not considered to be the "best" resource areas in a municipality, they may contain large quantities of sand and gravel and should be considered an integral component of the aggregate supply of the municipality.

Areas of tertiary significance are indicated on the map by a dashed line but have no shading. They are neither rated nor considered to be important resource areas because of their low available resources, or because of possible difficulties in extraction. Such areas may be useful for local needs but are unlikely to support large-scale development.

The process by which deposits are evaluated and selected involves the consideration of two sets of criteria. The main selection criteria are site specific, related to the characteristics of individual deposits. Factors such as deposit size, aggregate quality, and deposit location and setting are considered in the selection of those deposits best suited for extractive development. A second set of criteria involves the assessment of local aggregate resources in relation to the quality, quantity, and distribution of resources in the region in which the municipality is located. The intent of such a process of evaluation is to ensure the continuing availability of sufficient resources to meet possible future demands.

SITE SPECIFIC CRITERIA

DEPOSIT SIZE

Ideally, selected deposits should contain available sand and gravel resources large enough to support a commercial pit operation using a stationary or portable processing plant. In practice, much smaller deposits may be of significant value depending on the overall reserves in the rest of the municipality. Generally, deposits in Class 1, i.e. those thicker than 20 feet (6m) and containing more than 35 percent crushable gravel are considered to be most favourable for commercial development. Thinner deposits may be valuable in municipalities with low total resources.

AGGREGATE QUALITY

The limitations of natural aggregates for various uses result from variations in the lithology of the particles composing the deposit, and from variations in the size distribution of these particles.

Four indicators of the quality of aggregate may be included in the symbol for each deposit on Map 1. They are: gravel content (G or S); fines (C); oversize (O); and lithology (L).

Three of the indicators deal with grain size distribution. The gravel content (G or S) indicates the suitability of aggregate for various uses. Deposits containing at least 35 percent gravel in addition to a minimum of 20 percent material greater than the 26.5 mm sieve are considered to be the most favourable extractive sites, since this content is the minimum from which crushed products can be economically produced.

Excess fines (or high silt and clay content) may severely limit the potential use of an aggregate. Fines content in excess of 10 percent may impede drainage in road sub-base aggregate and render it more susceptible to the effects of frost action. In asphaltic aggregate, excess fines hinder the bonding of particles. Deposits known to have a high fines content are indicated by a "C" in the quality portion of the Deposit Symbol.

Deposits containing more than 20 percent oversize material (greater than 4 inches (10 cm) in diameter) may also have use limitations. The oversize component is unacceptable for all concrete aggregate and for road-building aggregate, so it must be either crushed or removed during processing. Deposits known to have an appreciable oversize component are indicated by an "O" in the quality portion of the Deposit Symbol.

The other indicator of the quality of an aggregate is lithology. Just as the unique physical and chemical properties of bedrock formations determine their value for use as crushed rock, so do various lithologies of particles in a sand and gravel deposit determine its suitability for various uses. The presence of objectionable lithologies such as chert, siltstone, and shale, even in relatively small amounts, can result in a reduction in the quality of an aggregate, especially for high-quality uses such as concrete or structures. Deposits known to contain objectionable lithologies are indicated by an "L" in the quality component of the Deposit Symbol.

If the Deposit Symbol indicates either "C", "O", or "L" or any combination, the quality of the deposit is considered to be reduced for some uses of the aggregate. No attempt has been made to quantify the degree of limitation imposed. Assessment of the four indicators is made from published data, from data contained in files of the Ontario Ministry of Transportation and Communications and the Engineering and Terrain Geology Section of the Ontario Geological Survey, and from field observations. The Engineering Materials Office of the Ontario Ministry of Transportation and Communications has recently compiled a detailed assessment of aggregate suitability for selected areas in southern Ontario. This material has been consulted extensively in preparation of the inventory reports.

Analyses of unprocessed samples obtained from test holes and pits have been plotted on grain size distribution graphs. On the graphs are the gradation specification envelopes for Ontario Ministry of Transportation and Communications' products — Granular Base Course A,B, and C; and Hot-Laid Asphaltic Sand Nos. 1, 2, 3, 4, 5, 6 and 8. By plotting the gradation curves with respect to the specification envelopes, it can be determined how well the unprocessed sampled material meets the criteria for each product.

LOCATION AND SETTING

The location and setting of a resource area has a direct influence on its value for possible extraction. The evaluation of a deposit's setting is made on the basis of those natural and man-made features which may limit or prohibit extractive development.

First, the physical context of the deposit is considered. Deposits with some physical constraint on extractive development, such as thick overburden or high water table, are less valuable resource areas because of the difficulties involved in resource recovery. Second, permanent man-made features, such as roads, railways, power lines, and housing developments, which are built on a deposit, may prohibit its extraction. The constraining effect of legally required setbacks surrounding such features is included in the evaluation. A quantitative assessment of these constraints can be made by measurement of their areal extent directly from the topographic maps. The area rendered unavailable by these features is shown for each resource area in Table 3 (Column 3).

The assessment of sand and gravel deposits and bedrock resource areas with respect to local land use and to private land ownership is an important component of the general evaluation process. These aspects of the evaluation process are not considered further in this report but readers are encouraged to discuss them with personnel of the pertinent District Office of the Ontario Ministry of Natural Resources.

REGIONAL CONSIDERATIONS

In selecting sufficient areas for resource development, it is important to assess both the local and the regional resource base, and to forecast future production and demand patterns.

Some appreciation of future aggregate requirements in an area may be gained by assessing its present production levels and by forecasting future production trends. Such an approach is based on the assumptions that production levels in an area closely reflect the demand and that the present production "market share" of an area will remain at roughly the same level.

The aggregate resources in the region surrounding a municipality should be assessed in order to properly evaluate specific resource areas and to adopt optimum resource management plans. For example, a municipality that has large resources in comparison to its surrounding region constitutes a regionally significant resource area. Municipalities with high resources in proximity to large demand centres, such as metropolitan areas, are special cases.

Although an appreciation of the regional context is required to develop comprehensive resource management techniques, such detailed evaluation is beyond the scope of this report. The selection of resource areas made in this study is based primarily on geological data or on considerations outlined in preceding sections.

MAP 3: BEDROCK RESOURCES

Map 3 is an interpretative map derived from bedrock geology, bedrock topography, drift thickness maps, water well data from the Ontario Ministry of the Environment, oil and gas well data from the Petroleum Resources Section (Ontario Ministry of Natural Resources), and from geotechnical test hole data from various sources. Map 3 is based on concepts similar to those outlined for Maps 1 and 2, but displays both the inventory and evaluation on the one map.

The geological boundaries of the bedrock units are shown by a dashed line. Isolated outcrops are indicated by an "X". Three sets of contour lines delineate areas of less than 3 feet (1 m) of drift, areas of 3 to 25 feet (1 to 8 m) of drift, and areas of 25 to 50 feet (8 to 15 m) of drift. The extent of the areas of thin drift are shown by three shades. The darkest shade indicates areas where bedrock outcrops or is within 3 feet (1 m) of the ground surface. These areas constitute potential resource areas of primary significance because of their easy access. The medium shade indicates areas where drift cover is up to 25 feet (8 m) thick. Quarrying is possible in this depth of overburden and these also represent potential resource areas. The lightest shade indicates bedrock areas overlain by 25 to 50 feet (8 to 15 m) of overburden. These latter areas constitute resources which have extractive value only in specific circumstances. Outside of these delineated areas the bedrock can be assumed to be covered by more than 50 feet (15 m) of overburden, a depth generally considered to be too great to allow economic extraction (unless part of the overburden is composed of economically attractive sand and gravel deposits).

Other inventory information presented on Map 3 is designed to give an indication of the present level of extractive activity in the municipality. Those areas which are licenced for extraction under The Pits and Quarries Control Act, 1971 are shown by a solid outline and identified by a number which refers to the quarry descriptions in Table 5. Each description notes the owner, location, and licenced acreage of the quarry and an estimate of face height. Unlicenced quarries (abandoned quarries or wayside quarries operating on demand under authority of a permit) are also identified and numbered on Map 3 and described in Table 5. One additional symbol appears on the map: an open dot indicates the location of a selected well which penetrates bedrock. The overburden thickness is shown in feet beside the open dot.

SELECTION CRITERIA

Criteria equivalent to those used for sand and gravel deposits are used to select bedrock areas most favourable for extractive development.

The evaluation of bedrock resources is made primarily on the basis of performance and suitability data established by laboratory testing at the Ontario Ministry of Transportation and

Communications. The main characteristics and uses of the bedrock formations found in southern Ontario are summarized in Appendix D.

Deposit "size" is related directly to the areal extent of thin drift cover overlying favourable bedrock formations of sufficient thickness to support quarry operations. Since vertical and lateral variations in bedrock units are much more gradual than in sand and gravel deposits, the quality and quantity of the resource is usually consistent over large areas.

Quality of the aggregate derived from specific bedrock units is established by the performance standards previously mentioned. Location and setting criteria and regional considerations are identical to those for sand and gravel deposits.

SELECTED RESOURCE AREAS

Selection of Bedrock Resource Areas has been restricted to a single level of significance. Three factors support this approach. First, quality and quantity variations are gradual. Second, the areal extent of a given quarry operation is much smaller than that of a sand and gravel pit producing an equivalent tonnage of material, and third, since crushed bedrock has a higher unit value than sand and gravel, longer haul distances can be considered. These factors allow the identification of alternative sites having similar development potential. The Selected Areas are shown on Map 3 by a line pattern and the calculated available tonnages are given in Table 6.

Selected Bedrock Resource Areas shown on Map 3 are not permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major bedrock resource is known to exist. Such a resource area may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

PART III - ASSESSMENT OF AGGREGATE RESOURCES IN THE TOWNSHIP OF NORWICH

LOCATION AND POPULATION

The Township of Norwich occupies 107,072 acres (43 332 ha) in southeastern Oxford County. It is bounded by the townships of Blandford-Blenheim, Burford, Delhi, Norfolk and Southwest Oxford on the north, east, southeast, south and west, respectively. The township was created from the geographic townships of East Oxford, North Norwich and South Norwich when Oxford County was restructured in 1975. The township is shown on portions of the Woodstock (40 P/2) and Tillsonburg (40 1/15) map sheets of the National Topographic System, at a scale of 1:50 000.

The City of Woodstock and the Town of Tillsonburg are situated on the northwest and southwest boundaries of the township, respectively. The two municipalities had respective populations of 26 390 and 10 099 in 1980 (Ontario Ministry of Intergovernmental Affairs 1981). The population of Woodstock has increased by less than 6 percent since 1973, while Tillsonburg, has shown a large increase of close to 60 percent during the same time period (Ontario Ministry of Intergovernmental Affairs 1981; Ontario Ministry of Treasury, Economics and Intergovernmental Affairs 1974). Population centres within the township include the settlements of Norwich, Otterville and Burgessville.

The population of the township (exclusive of Woodstock and Tillsonburg) was 9707 in 1980. Figures from previous years indicate that the population has increased only slightly since 1973 (Ontario Ministry of Intergovernmental Affairs 1981; Ontario Ministry of Treasury, Economics and Intergovernmental Affairs 1974). A portion of this population is located in the communities of Norwich and Otterville. However, most of the inhabitants are engaged in farming. Continued population growth in both urban and rural areas may require additional production from local aggregate supplies.

Access to the township is provided by King's Highways 401, 2, 53 and 59 as well as by gravel-surfaced township roads and paved county roads. Rail access is provided by lines of the Canadian National Railways and Conrail.

PHYSIOGRAPHY AND SURFICIAL GEOLOGY

The Township of Norwich was affected by glaciers flowing out of both the Lake Huron and Lake Erie basins giving rise to a terrain referred to as the interlobate zone. During retreat of the two glaciers, the area between the lobes became ice free relatively early. Because of its elevation, this area is believed to have existed as an island, surrounded by a sea of ice (Taylor 1913). However, Cowan (1975) reports that this zone has probably been invaded several times by the ice sheets, even during periods of glacial retreat.

These advances resulted in the mixing of sediment giving lithologically similar tills (Cowan 1975). The two youngest tills, the Tavistock Till and Port Stanley Till, were deposited by the Huron and Erie lobes, respectively. The Huron lobe advanced from the northwest while the Erie lobe advanced from the southeast. The Port Stanley is the most extensive till deposit in the township while the Tavistock covers only the northwestern corner. The Tavistock is a stony, silt or sandy silt till while the Port Stanley is a clayey silt or silt till. These tills have little value as aggregate because of the excess silt and clay content.

An older till which is present only locally at the surface, underlies the surficial material in much of the township, and is referred to as the Catfish Creek Till. It is similar to the Tavistock Till as it is a stony sandy silt till (Barnett 1980; Cowan 1975). Its stony nature is favourable for reworking into glaciofluvial sands and gravels of considerable economic importance (Cowan 1975).

A series of moraines referred to as the Mount Elgin Ridges were deposited during successive temporary halts of the retreating Erie lobe (Chapman and Putnam 1966, p. 233). Within the township, from north to south, these ridges are represented by the Ingersoll, St. Thomas, Norwich and Tillsonburg moraines. They are composed predominantly of glacial till, however, small pockets of ice-contact sand may be present.

Between these ridges glacial meltwaters deposited glaciofluvial sand and gravel. The outwash and ice-contact deposits often reflect the nature of the till with which they are associated. This relationship is indeed prevalent in the Township of Norwich as the sands and gravels associated with the Port Stanley Till are fine grained and of low economic importance. However, the glaciofluvial deposits related to the Catfish Creek Till reflect its stony nature and constitute economically valuable resources. These older sand and gravel deposits have normally been buried beneath younger till except in areas eroded by younger meltwater channels. The extent of the deposits is difficult to determine because of their buried nature.

Glacial meltwaters flowed between the moraine ridges and eventually emptied into large glacial lakes. The most extensive glaciolacustrine feature in the Township of Norwich is the Norfolk Sand Plain (Chapman and Putnam 1966, p. 251). These deltaic and nearshore sands were deposited in glacial Lake Whittlesey and blanket much of the southern portion of the township. The normally fine- to medium-grained sands have little aggregate potential.

Postglacial erosional and depositional processes have been of relatively minor importance in modifying the physiography of the township. Older alluvial sediments occupy the Big Otter Creek valley at several locations. Poor drainage in several depressions has led to the development of a number of marshes within the township.

EXTRACTIVE ACTIVITY

At least a half dozen sand and gravel pits have been opened in the Township of Norwich. The majority are located in an ice-contact deposit in the central portion of the township. At the time of writing 6 pits were licenced to operate, including one clay pit. The total licenced area of these sources is 126.2 acres (51.1 ha).

The Township of Norwich was designated in 1975 under The Pits and Quarries Control Act, 1971. Since the designation of the township, records of the total annual production of sand and gravel from all licenced sources have been maintained by the Simcoe District Office of the Ontario Ministry of Natural Resources. The average annual production between 1977 and 1980 has been 94,000 tons (85 000 tonnes).

SELECTED SAND AND GRAVEL RESOURCE AREAS

The sand and gravel deposits selected for possible resource protection in the Township of Norwich are shown on Map 2. An outwash plain and two ice-contact deposits have been selected as Sand and Gravel Resource Areas of Primary Significance.

The Selected Sand and Gravel Resource Areas include approximately 345 acres (140 ha) currently available for extraction and have estimated sand and gravel resources of 21 million tons (19 million tonnes). The Selected Areas occupy 1 percent of the total area of sand and gravel deposits in the township and represent 2 percent of the total resource tonnage.

SELECTED SAND AND GRAVEL RESOURCE AREA 1

Selected Sand and Gravel Resource Area 1 is a partially buried ice-contact deposit situated 1.5 miles (2.4 km) southwest of Holbrook. It has been the most extensively utilized deposit in the township. Four licenced pits have been opened in the area. Of these, pit no. 3 is the only one currently active. Pit no. 2 is a recent extension of the aforementioned pit.

Faces in the pits range in height from 15 to 40 feet (5 to 12 m) and expose poorly to well sorted gravelly sand. Throughout the deposit the gravel beds are extremely variable and occur as lenses and pockets within the sand. A face in pit no. 3 exposes 8 feet (2 m) of gravel overlain by 9 feet (3 m) of sand. The aggregate is capped by 3 to 10 feet (1 to 3 m) of till. Up to 20 feet (6 m) of aggregate is dredged from below the pit floor.

The material in the pits has been used mainly for road construction products in the past. The type of product best produced from this deposit includes Granular Base Course B and C, and fill. It contains some crushable gravel and in sections may be suitable for Granular Base Course A with sand control. The sand grades too coarse in some sections and too silty in others for hot-laid asphalt and must be blended with other material. The high variability of the deposit and, the presence of chert and silt restrict the quality of the product.

Resource Area 1 occupies 110 acres (44 ha), exclusive of the licenced properties. Cultural setbacks and previous extraction reduce the area currently available to 80 acres (32 ha). Assuming an average deposit thickness of 35 feet (11 m), available resources are estimated to be 7 million tons (6 million tonnes).

It should be stressed, however, that the extent and distribution of the buried portion of this deposit has been based largely on topographic considerations, as little subsurface data exist. Therefore, the boundary of the buried portion is approximate and may require further testing to determine its true position.

SELECTED SAND AND GRAVEL RESOURCE AREA 2

Selected Sand and Gravel Resource Area 2 consists of a buried ice-contact deposit situated near the eastern boundary of the township. The deposit lies within a ridge and is overlain by 3 to 15 feet (1 to 5 m) of till and stratified material (Cowan 1975, p. 62).

The gravel from pit no. 6 may be suitable for crushing and is used predominantly as road gravel. The Ontario Ministry of Transportation and Communications report that this material is suitable for Granular Base Course A and C. However, the material is too dirty for use as hot-laid asphalt, and blending is probably required. A chert content of 5 to 8 percent may restrict some uses of the aggregate.

Resource Area 2 occupies 132 acres (53 ha), exclusive of the licenced property. Previous extraction and cultural setbacks reduce the area currently available to 100 acres (40 ha). Assuming an average deposit thickness of 25 feet (8 m), available resources are estimated to be 6 million tons (5 million tonnes). The same limitations with respect to boundary placement exist for this buried deposit as in Resource Area 1.

SELECTED SAND AND GRAVEL RESOURCE AREA 3

Selected Sand and Gravel Reource Area 3 is an outwash plain deposit located on the western boundary of the township. The gravel deposit extends westward into the Township of Southwest Oxford, where it has also been selected as a Resource Area of Primary Significance.

However, the outwash in Norwich is believed to be of younger age than the partially buried gravels in Southwest Oxford. Therefore, deposit data should not be extrapolated from the widely utilized gravels to the west. No pits have been opened in this area, but water wells indicate that the thickness of gravel may be up to 26 feet (8 m).

The high water table present in the area will hamper extraction, and dredging will probably be required. Marshes overlie the outwash at several locations and the gravel may underlie the bog deposit found to the north of the Area. Chert may also restrict some uses of this material.

Resource Area 3 occupies 260 acres (105 ha). Cultural setbacks reduce the area currently available to 165 acres (67 ha). Assuming an average deposit thickness of 20 feet (6 m), available resources are estimated to be 8 million tons (7 million tonnes).

SAND AND GRAVEL RESOURCE AREAS OF SECONDARY SIGNIFICANCE

Three outwash deposits have been identified as Sand and Gravel Resource Areas of Secondary Significance. Although these deposits are not the "best" resources, they should be considered an integral component of the township's aggregate supply.

A large area, consisting of two outwash deposits located in the northwestern portion of the township, has been selected for possible resource protection. Two pits which are presently rehabilitated were opened in the deposit situated in the northeastern portion of the area. Extraction took place up to a depth of 8 feet (2 m) in fine to coarse outwash gravel (Cowan 1975). The adjoining deposit consists of sand, and water well data suggest a significant thickness of material. Two test holes sunk into the southern portion of this deposit yielded 20 feet (6 m) of medium to coarse sand. In places the sand may overlie and mask coarser outwash plain aggregate, so further investigation of the area may enlarge the total resource potential.

Only the portion of this deposit which shows potential for buried or surficial coarse aggregate has been selected on Map 2.

An ice-contact deposit located 1.5 miles (2.4 km) south of Holbrook has also been selected. The deposit is an east-west trending ridge and is predominantly a sand source. Data for the deposit are scarce, however, at one location a road-cut exposed 4 feet (1 m) of medium to coarse sand.

Perhaps the greatest potential for finding significant quanities of good quality sand and gravel lies in the location of buried deposits within the township. These deposits are often associated with ridges and are till covered. Additional subsurface exploration may increase the total resource potential of the township.

BEDROCK GEOLOGY

Bedrock underlying the Township of Norwich consists of limestone, dolostone and shale of Upper Silurian to Middle Devonian age. The formations subcrop in northwest-trending bands with the oldest bedrock underlying the northeast corner of the township. The distribution of the formations is shown on Map 3 after Sanford (1969).

The Salina and Bass Islands Formations were deposited during the Upper Silurian Period. The Salina Formation consists of shale and argillaceous dolostone with lenses of gypsum and other evaporitic minerals. It has been mined for gypsum at Drumbo nearby in the Township of Blandford-Blenheim. The younger Bass Islands Formation consists of thick-bedded, fine-crystalline brown dolostone that is well suited for the production of crushed stone (Hewitt 1972).

The Bois Blanc Formation, Detroit River Group and Dundee Formation are Devonian in age. The Bois Blanc Formation overlies the Bass Islands Formation and consists of medium-crystalline cherty limestone. It is suitable for the production of crushed stone, although a high chert content may restrict its uses.

The Detroit River Group consists of the Amherstburg and Lucas Formations, and is overlain by the Dundee Formation. The high purity limestone of the Lucas Formation is quarried for the production of lime, fluxstone and minor crushed stone in the nearby Beachville-Ingersoll area. The medium- to fine-grained limestone of the Dundee Formation is suitable for the production of crushed stone and portland cement.

Excessive overburden renders much of the bedrock underlying the township unavailable for quarrying. A small area of the Bois Blanc and Amherstburg Formations on the eastern boundary of the township is covered by less than 50 feet (15 m) of drift. However, the drift thickness generally exceeds 35 feet (11 m) and extraction of these formations is not considered economically viable at these depths. Another area located in the Big Otter Creek valley is covered by less than 50 feet (15 m) of drift, but its size and position in the valley would make extraction of the Dundee Formation difficult. Therefore, no bedrock resources have been selected.

SUMMARY

The Township of Norwich has possible resources of sand and gravel suitable for a number of aggregate uses. However, possible resources of crushable gravel are considered low. Three deposits of primary significance and three of secondary significance have been selected for possible resource protection in the township. Care should be taken to ensure the continued availability of as much of these Resource Areas as possible.

Bedrock of several formations underlies the township, however the great thickness of surficial materials overlying the bedrock prevents any areas from being selected for resource protection.

Enquiries regarding the Aggregate Resources Inventory of the Township of Norwich should be directed to the Ontario Ministry of Natural Resources either at the Simcoe District Office, 645 Norfolk Street North, Simcoe, Ontario, N3Y 3R2 (Tel. (519) 426-7650) or at the Southwestern Region Geological Office, 458 Central Avenue, London, Ontario, N6B 2E5 (Tel. (519) 433-8431).

TABLE 1 | TOTAL SAND AND GRAVEL RESOURCES, TOWNSHIP OF NORWICH

1 CLASS NO.	2 DEPOSIT TYPE (see Appendix C)	3 AREAL EXTENT Acres (Hectares)	4 ORIGINAL TONNAGE Millions of Tons (Tonnes)
1	G-IC	147 (60)	9 (8)
	S-IC	380 (154)	26 (24)
	S-LB	48 (19)	2 (2)
	S-LP	4650 (1880)	285 (260)
	G-OW	260 (105)	13 (12)
	S-OW	3250 (1320)	199 (180)
2	S-IC	36 (15)	1 (1)
	S-LP	15,000 (6100)	470 (425)
	G-OW	247 (100)	8 (7)
	S-OW	192 (78)	7 (6)
3	S-AL	540 (218)	11 (10)
	S-IC	148 (60)	3 (3)
	S-LP	520 (210)	11 (10)
	S-OW	1120 (455)	18 (16)
4	S-AL	60 (24)	<1 (<1)
	G-IC	28 (11)	<1 (<1)

TABLE 1 | TOTAL SAND AND GRAVEL RESOURCES, TOWNSHIP OF NORWICH

1 CLASS NO.	2 DEPOSIT TYPE (see Appendix C)	3 AREAL EXTENT Acres (Hectares)	4 ORIGINAL TONNAGE Millions of Tons (Tonnes)
	S-IC	48 (19)	<1 (<1)
	S-LP	48 (19)	<1 (<1)
	S-OW	780 (315)	8 (7)
		27,500 (11 100)	1070 (970)

N.B. Minor variations in above table are due to rounding of data.

TABLE 2 | SAND AND GRAVEL PITS, TOWNSHIP OF NORWICH

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 LICENCED AREAS Acres (Hectares)	7 FACE HEIGHT Feet (Metres)	8 % GRAVEL
LICENCED PITS							
1	W11-59	R. Pearson	26	2	32.0 (13.0)	30-40 (9-12)	25-35
2	–	Prouse Transport	25	2	26.0 (10.5)		not opened
3	W11-16	Prouse Transport	25	2	18.8 (7.6)	20-40 (6-12) dredged to 20 feet (6 m)	25-30
4	W11-41	Norwich Township	25	2	10.1 (4.1)	15-30 (5-9) dredged to 15 feet (5 m)	30
5	–	Helen and Dorothy Kleen	12 & 13	3	24.2 (9.8)	5-10 (2-3)	clay pit
6	W11-51	Norwich Township	pts. 1 & 2	4	15.1 (6.1)	20 (6) dredged to 15 feet (5 m)	35-40
					126.2 (51.1)		

TABLE 3 | SELECTED SAND AND GRAVEL RESOURCE AREAS, TOWNSHIP OF NORWICH

1 DEPOSIT NO.	2 UNLICENCED AREA Acres (Hectares)	3 CULTURAL SETBACKS Acres (Hectares)	4 EXTRACTED AREA Acres (Hectares)	5 AVAILABLE AREA Acres (Hectares)	6 ESTIMATED DEPOSIT THICKNESS Feet (Metres)	7 AVAILABLE AGGREGATE Millions of Tons (Tonnes)
1	110 (44)	25 (10)	5 (2)	80 (32)	35 (11)	7 (6)
2	132 (53)	27 (11)	5 (2)	100 (40)	25 (8)	6 (5)
3	260 (105)	95 (38)	0 (0)	165 (67)	20 (6)	8 (7)
	500 (202)	147 (60)	10 (4)	345 (140)		21 (19)

N.B. Minor variations in above table are due to rounding of data.

TABLE 4 TOTAL IDENTIFIED BEDROCK RESOURCES, TOWNSHIP OF NORWICH

1 **DRIFT THICKNESS** Feet (Metres)	2 **FORMATION**	3 **ESTIMATED DEPOSIT THICKNESS** Feet (Metres)	4 **AREAL EXTENT** Acres (Hectares)	5 **ORIGINAL TONNAGE** Millions of Tons (Tonnes)
3-25 (1-8)	Dundee	60 (18)	96 (39)	21 (19)
25-50 (8-15)	Dundee	60 (18)	215 (87)	46 (42)
			310 (126)	67 (61)
25-50 (8-15)	Detroit River Group (Amherstburg Formation)	60 (18)	250 (101)	54 (49)
25-50 (8-15)	Bois Blanc	60 (18)	159 (64)	34 (31)
			720 (290)	155 (141)

N.B. Minor variations in above table are due to rounding of data.

TABLE 5 | QUARRIES, TOWNSHIP OF NORWICH

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 LICENCED AREA Acres (Hectares)	7 FACE HEIGHT Feet (Metres)

– NONE –

TABLE 6 | SELECTED BEDROCK RESOURCE AREAS, TOWNSHIP OF NORWICH

1 DEPOSIT NO.	2 DEPTH OF OVERBURDEN Feet (Metres)	3 UNLICENCED AREA Acres (Hectares)	4 CULTURAL SETBACKS Acres (Hectares)	5 EXTRACTED AREA Acres (Hectares)	6 AVAILABLE AREA Acres (Hectares)	7 ESTIMATED WORKABLE THICKNESS Feet (Metres)	8 AVAILABLE RESOURCES Millions of Tons (Tonnes)

– NONE –

TABLE 7 | SUMMARY OF TEST HOLE DATA, TOWNSHIP OF NORWICH

TEST HOLE NUMBER: NW-TH-1

LOCATION: Lot 19, Conc. 4, East Oxford Geographic Township

ELEVATION: Approximately 958 feet (292 m) a.s.l.

DATE: October 15, 1980

DEPTH feet (metres)	DESCRIPTION
5 (2)	coarse sand and small pebbles
10 (3)	6-inch (15 cm) clay layer then wet coarse sand and pebbles
15 (5)	medium sand grading to very coarse; layer of every fine sand at tip of split spoon
20 (6)	clean coarse sand grading to a fine sand with a clayey layer beneath

TEST HOLE NUMBER: NW-TH-2

LOCATION: Lot 19, Conc. 4, East Oxford Geographic Township

ELEVATION: Approximately 958 feet (292 m) a.s.l.

DATE: October 15, 1980

DEPTH feet (metres)	DESCRIPTION
5 (2)	clean medium sand
10 (3)	clean medium sand mixed with small stones 1 inch (2.5 cm) and pebbles; clay layer
15 (5)	coarse sand and gravel (rounded)
20 (6)	coarse sand grading to gravel
25 (8)	grey clay till

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APPENDIX B - GLOSSARY

ABRASION RESISTANCE

Tests such as the Los Angeles Abrasion Test are used to measure the ability of aggregate to resist crushing and pulverizing under conditions similar to those encountered in processing and use. Measuring resistance is an important component in the evaluation of the quality and prospective uses of aggregate. Hard, durable material is preferred for road building.

ABSORPTION CAPACITY

Related to the porosity of the rock types of which an aggregate is composed. Porous rocks are subject to disintegration when absorbed liquids freeze and thaw, thus decreasing the strength of the aggregate.

AGGREGATE

Any hard, inert, construction material (sand, gravel, shells, slag, crushed stone or other mineral material) used for mixing in various-sized fragments with a cement or bituminous material to form concrete, mortar, etc., or used alone for road building or other construction. Synonyms include mineral aggregate and granular material.

ALKALI-AGGREGATE REACTION

A chemical reaction between the alkalies of portland cement and certain minerals found in rocks used for aggregate. Alkali-aggregate reactions are undesirable because they can cause expansion and cracking of concrete. Although perfectly suitable for building stone and asphalt applications, alkali-reactive aggregates should be avoided for structural concrete uses.

BLENDING

Required in cases of extreme coarseness, fineness or other irregularities in the gradation of unprocessed aggregate. Blending is done with approved sand-sized aggregate in order to satisfy the gradation requirements of the material.

CAMBRIAN

The first period of the Paleozoic Era, thought to have covered the time between 570 and 500 million years ago; the Cambrian precedes the Ordovician Period.

CLAST

An individual constituent, grain or fragment of a sediment or rock, produced by the mechanical weathering of a larger rock mass. Synonyms include particle and fragment.

CRUSHABLE AGGREGATE

Unprocessed gravel containing a minimum of 35 percent coarse aggregate larger than the No. 4 sieve (4.75 mm) as well as a minimum of 20 percent greater than the 26.5 mm sieve.

DELETERIOUS LITHOLOGY

A general term used to designate those rock types which are chemically or physically unsuited for use as construction or road-building aggregates. Such lithologies as chert, shale, siltstone and sandstone may deteriorate rapidly when exposed to traffic and other environmental conditions.

DEVONIAN

A period of the geological past thought to have covered the span of time between 395 and 345 million years ago, following the Silurian Period. Rocks formed in the Devonian Period are among the youngest found in Ontario.

DOLOSTONE

A carbonate sedimentary rock consisting chiefly of the mineral dolomite and containing relatively little calcite (dolostone is also known as dolomite).

DRIFT

A general term for all unconsolidated rock debris transported from one place and deposited in another; distinguished from underlying bedrock. In North America, glacial activity has been the dominant mode of transport and deposition of drift. Synonyms include overburden and surficial deposit.

DRUMLIN

A low, smoothly rounded, elongated hill, mound, or ridge composed of glacial materials. These landforms were deposited beneath an advancing ice sheet, and were shaped by its flow.

EOLIAN

Pertaining to the wind, especially with respect to landforms whose constituents were transported and deposited by wind activity. Sand dunes are an example of an eolian landform.

FINES

A general term used to describe the size fraction of an aggregate which passes (is finer than) the No. 200 mesh screen (.075 mm). Also described informally as "dirt", these particles are in the silt and clay size range.

GLACIAL LOBE

A tongue-like projection from the margin of the main mass of an ice cap or ice sheet. During the Pleistocene Epoch several lobes of the Laurentide continental ice sheet occupied the Great Lakes basins. These lobes advanced and retreated numerous times during the Pleistocene, producing the complex arrangement of glacial material and landforms found in southern Ontario.

GRADATION

The proportion of material of each particle size, or the frequency distribution of the various sizes which constitute a sediment. The strength, durability, permeability and stability of an aggregate depend to a great extent on its gradation. The size limits for different particles are as follows:

Boulder	**more than 200 mm**
Cobbles	**75-200 mm**
Coarse Gravel	**26.5-75 mm**
Fine Gravel	**4.75-26.5 mm**
Coarse Sand	**2-4.75 mm**
Medium Sand	**0.425-2 mm**
Fine Sand	**0.075-0.425 mm**
Silt, Clay	**less than 0.075 mm**

GRANULAR BASE COURSE

Components of the pavement structure of a road, which are placed on the subgrade and are designed to provide strength, stability and drainage, as well as support for surfacing materials. Several types have been defined: Granular Base Course A consists of crushed and processed aggregate and has relatively stringent quality standards in comparison to Granular Base Course B and C which are usually pit-run or other unprocessed aggregate.

HOT-LAID (OR ASPHALTIC) AGGREGATE

Bituminous, cemented aggregates used in the construction of pavements either as surface or bearing course (H.L. 1, 3 and 4), or as binder course (H.L. 2, 6 and 8) used to bind the surface course to the underlying granular base course.

LITHOLOGY

The description of rocks on the basis of such characteristics as color, structure, mineralogic composition and grain size. Generally, the description of the physical character of a rock.

MELTWATER CHANNEL

A drainage way, often terraced, produced by water flowing away from a melting glacier margin.

ORDOVICIAN

An early period of the Paleozoic Era thought to have covered the span of time between 500 and 435 million years ago.

PALEOZOIC ERA

One of the major divisions of the geologic time scale thought to have covered the time between 570 and 230 million years ago, the Paleozoic Era (or Ancient Life Era) is subdivided into six geologic periods, of which only four (Cambrian, Ordovician, Silurian and Devonian) can be recognized in southern Ontario.

PETROGRAPHIC EXAMINATION

An aggregate quality test based on known field performance of various rock types. The test result is a Petrographic Number (P.N.). The higher the P.N. the lower the quality of the aggregate.

PLEISTOCENE

An Epoch of the recent geological past including the time from approximately 1.8 million years ago to 7000 years ago. Much of the Pleistocene was characterized by extensive glacial activity and is popularly referred to as the "Great Ice Age".

POSSIBLE RESOURCE

Reserve estimates based largely on broad knowledge of the geological character of the deposit and for which there are few, if any samples or measurements. The estimates are based on assumed continuity or repetition for which there are reasonable geological indications.

SHALE

A fine-grained, sedimentary rock formed by the consolidation of clay, silt or mud and characterized by well developed bedding planes, along which the rock breaks readily into thin layers. The term shale is also commonly used for fissile claystone, siltstone and mudstone.

SILURIAN

An early period of the Paleozoic Era thought to have covered the time between 435 and 395 million years ago. The Silurian follows the Ordovician Period and precedes the Devonian Period.

SOUNDNESS

The ability of the components of an aggregate to withstand the effects of various weathering processes and agents. Unsound lithologies are subject to disintegration caused by the expansion of absorbed solutions. This may seriously impair the performance of road-building and construction aggregates.

TILL

Unsorted and unstratified rock debris, deposited directly by glaciers, and ranging in size from clay to large boulders.

WISCONSINAN

Pertaining to the last glacial period of the Pleistocene Epoch in North America. The Wisconsinan began approximately 100 000 years ago and ended approximately 7000 years ago. The glacial deposits and landforms of southern Ontario are predominantly the result of glacial activity during the Wisconsinan Stage.

APPENDIX C - GEOLOGY OF SAND AND GRAVEL DEPOSITS

The type, distribution, and extent of sand and gravel deposits in southern Ontario are the result of extensive glacial and glacially influenced activity in Wisconsinan time during the Pleistocene Epoch, approximately 100 000 to 7000 years ago. The deposit types reflect the different depositional environments that existed during the melting and retreat of the continental ice masses, and can readily be differentiated on the basis of their morphology, structure, and texture. The deposit types are described below.

GLACIOFLUVIAL DEPOSITS

These deposits can be divided into two broad categories: those that were formed in contact with (or in close proximity to) glacial ice, and those that were deposited by meltwaters carrying materials beyond the ice margin.

ICE-CONTACT TERRACES (ICT)

These are glaciofluvial features deposited between the glacial margin and a confining topographic high, such as the side of a valley. The structure of the deposits may be similar to that of outwash deposits, but in most cases the sorting and grading of the material is more variable and the bedding is discontinuous due to extensive slumping. The probability of locating large amounts of crushable aggregate is moderate, and extraction may be expensive due to the variability of the deposits both in terms of quality and grain size distribution.

KAMES (K)

Kames are defined as mounds of poorly sorted sand and gravel deposited by meltwater in depressions or fissures on the ice surface or at its margin. During glacial retreat, the melting of supporting ice causes collapse of the deposits producing internal structures characterized by bedding discontinuities. The deposits consist mainly of irregularly bedded and crossbedded, poorly sorted sand and gravel. The present forms of the deposits include single mounds, linear ridges (crevasse fillings) or complex groups of landforms. The latter are occasionally described as "undifferentiated ice-contact stratified drift" (IC) when detailed subsurface information is unavailable. Since kames commonly contain large amounts of fine-grained material and are characterized by considerable variability, there is generally a low to moderate probability of discovering large amounts of good-quality, crushable aggregate. Extractive problems encountered in these deposits are mainly the excessive variability of the aggregate and the rare presence of excess fines (silt- and clay-sized particles).

ESKERS (E)

Eskers are narrow, sinuous ridges of sand and gravel deposited by meltwaters flowing in tunnels within or at the base of glaciers, or in channels on the ice surface. Eskers vary greatly in size. Many, though not all eskers consist of a central core of poorly sorted and stratified gravel characterized by a wide range in grain size. The core material is often draped on its flanks by better sorted and stratified sand and gravel. The deposits have a high probability of containing a large proportion of crushable aggregate, and since they are generally built above the surrounding ground surface, are convenient extraction sites. For these reasons esker deposits have been traditional aggregate sources throughout southern Ontario, and are significant components of the total resources of many areas.

Some planning constraints and opportunities are inherent in the nature of the deposits. Because of their linear nature, the deposits commonly extend across several property boundaries leading to unorganized extractive development at numerous small pits. On the other hand, because of their form, eskers can be easily and inexpensively extracted and are amenable to rehabilitation and sequential land use.

UNDIFFERENTIATED ICE-CONTACT STRATIFIED DRIFT (IC)

This designation may include deposits from several ice-contact, depositional environments which usually form extensive, complex landforms. It is not feasible to identify individual areas of coarse-grained material within such deposits due to their lack of continuity and grain size variability. They are given a qualitative rating based on existing pit and other subsurface data.

OUTWASH (OW)

Outwash deposits consist of sand and gravel laid down by meltwaters beyond the margin of the ice lobes. The deposits occur as sheets or as terraced valley fills (valley trains) and may be very large in extent and thickness. Well developed outwash deposits have good horizontal bedding and are uniform in grain size distribution. Outwash deposited near the glacier's margin is much more variable in texture and structure. The probability of locating useful crushable aggregates in outwash deposits is moderate to high depending on how much information on size, distribution and thickness is available.

ALLUVIUM (AL)

Alluvium is a general term for clay, silt, sand, gravel, or similar unconsolidated material deposited during postglacial time by a stream as sorted or semi-sorted sediment, on its bed or on its floodplain. The probability of locating large amounts of crushable aggregate in alluvial deposits is low, and it has generally low value due to the presence of excess silt- and clay-sized material. There are few large postglacial alluvium deposits in Ontario.

GLACIOLACUSTRINE DEPOSITS

GLACIOLACUSTRINE BEACH DEPOSITS (LB)

These are relatively narrow, linear features formed by wave action at the shores of glacial lakes that existed at various times during the deglaciation of southern Ontario. Well developed lacustrine beaches are usually less than 20 feet (6 m) thick. The aggregate is well sorted and stratified and sand-sized material commonly predominates. The composition and size distribution of the deposit depends on the nature of the source material. The probability of obtaining crushable aggregate is high when the material is developed from coarse-grained materials such as a stony till, and low when developed from fine-grained materials. Beaches are relatively narrow, linear deposits, so that extractive operations are often numerous and extensive.

GLACIOLACUSTRINE DELTAS (LD)

These features were formed where streams or rivers of glacial meltwater flowed into lakes and deposited their suspended sediment. In southern Ontario such deposits tend to consist mainly of sand and abundant silt. However, in near-ice and ice-contact positions, coarse material may be present. Although deltaic deposits may be large, the probability of obtaining coarse material is generally low.

GLACIOLACUSTRINE PLAINS (LP)

The nearly level surface marking the floor of an extinct glacial lake. The sediments which form the plain are predominantly fine to medium sand, silt, and clay, and were deposited in relatively deep water. Lacustrine deposits are generally of low value as aggregate sources due to their fine grain size and lack of crushable material. In some aggregate-poor areas, lacustrine deposits may constitute valuable sources of fill and some granular base course aggregate.

GLACIAL DEPOSITS

END MORAINES (EM)

These are belts of glacial drift deposited at, and parallel to, glacier margins. End moraines commonly consist of ice-contact stratified drift and in such instances are usually called kame moraines. Kame moraines commonly result from deposition between two glacial lobes (interlobate moraines). The probability of locating aggregates within such features is moderate to low. Exploration and development costs are high. Moraines may be very large and contain vast aggregate resources, but the location of the best resource areas within the moraine is usually poorly defined.

EOLIAN DEPOSITS

WINDBLOWN DEPOSITS (WD)

Windblown deposits are those formed by the transport and deposition of sand by winds. The form of the deposits ranges from extensive, thin layers to well developed linear and crescentic ridges known as dunes. Most windblown deposits in southern Ontario are derived from, and deposited on, pre-existing lacustrine sand plain deposits. Windblown sediments almost always consist of fine to coarse sand and are usually well sorted. The probability of locating crushable aggregate in windblown deposits is very low.

APPENDIX D - GEOLOGY OF BEDROCK DEPOSITS

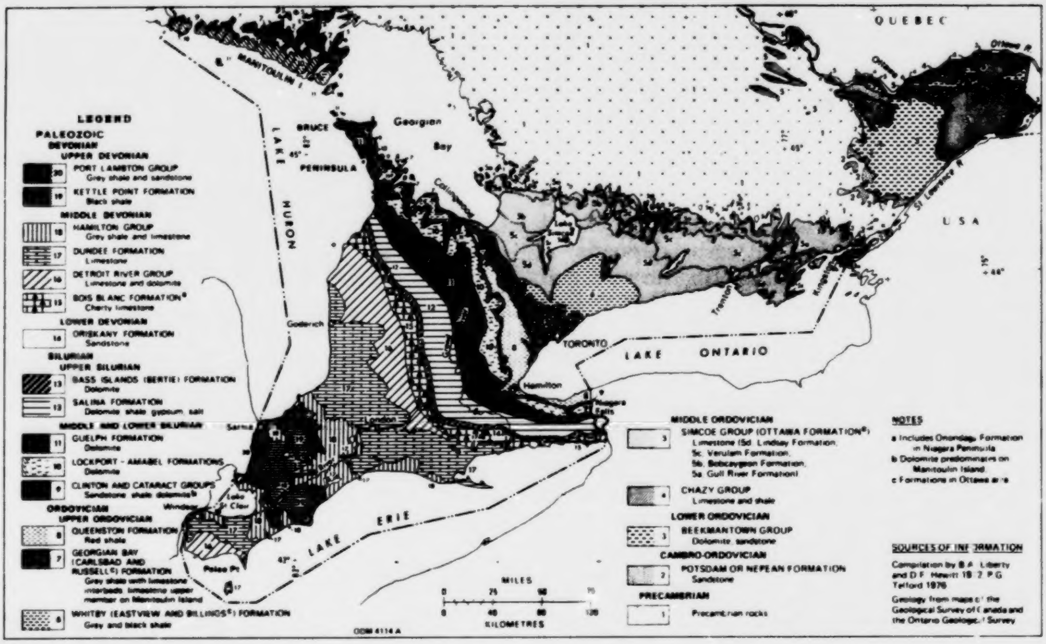

QUEBEC
Ottawa R.
MANITOULIN I.
BRUCE PENINSULA
Georgian Bay
LAKE HURON
Goderich
Sarnia
Windsor
Lake St Clair
Pelee Pt
LAKE ERIE
London
Hamilton
TORONTO
Niagara Falls
LAKE ONTARIO
Kingston
St Lawrence R.
U S A
LEGEND
PALEOZOIC
DEVONIAN
UPPER DEVONIAN
20 PORT LAMBTON GROUP Grey shale and sandstone
19 KETTLE POINT FORMATION Black shale
MIDDLE DEVONIAN
18 HAMILTON GROUP Grey shale and limestone
17 DUNDEE FORMATION Limestone
16 DETROIT RIVER GROUP Limestone and dolomite
15 BOIS BLANC FORMATION a Cherty limestone
LOWER DEVONIAN
14 ORISKANY FORMATION Sandstone
SILURIAN
UPPER SILURIAN
13 BASS ISLANDS (BERTIE) FORMATION Dolomite
12 SALINA FORMATION Dolomite shale gypsum salt
MIDDLE AND LOWER SILURIAN
11 GUELPH FORMATION Dolomite
10 LOCKPORT - AMABEL FORMATIONS Dolomite
9 CLINTON AND CATARACT GROUPS Sandstone shale dolomite b
ORDOVICIAN
UPPER ORDOVICIAN
8 QUEENSTON FORMATION Red shale
7 GEORGIAN BAY (CARLSBAD AND RUSSELL c) FORMATION Grey shale with limestone interbeds. limestone upper member on Manitoulin Island
6 WHITBY (EASTVIEW AND BILLINGS c) FORMATION Grey and black shale
MIDDLE ORDOVICIAN
5 SIMCOE GROUP (OTTAWA FORMATION c) Limestone (5d. Lindsay Formation, 5c. Verulam Formation, 5b. Bobcaygeon Formation, 5a. Gull River Formation)
4 CHAZY GROUP Limestone and shale
LOWER ORDOVICIAN
3 BEEKMANTOWN GROUP Dolomite, sandstone
CAMBRO-ORDOVICIAN
2 POTSDAM OR NEPEAN FORMATION Sandstone
PRECAMBRIAN
1 Precambrian rocks
NOTES
a Includes Onondaga Formation in Niagara Peninsula
b Dolomite predominates on Manitoulin Island
c Formations in Ottawa area
SOURCES OF INFORMATION
Compilation by B.A. Liberty and D.F. Hewitt 1972 P.G. Telford 1976
Geology from maps of the Geological Survey of Canada and the Ontario Geological Survey
MILES
KILOMETRES
ODM 4114 A

Figure 2 - Bedrock Geology of Southern Ontario

BEDROCK SUITABLE FOR CRUSHED STONE PRODUCTS

BASS ISLANDS FORMATION (UPPER SILURIAN)

(Includes the Bertie Formation of the Niagara Peninsula) Composition: Medium- to massive-bedded, aphanitic, brown dolostone with shaly partings. Thickness: 35 to 60 feet (11 to 18m) near Hagersville. Uses: Quarried for crushed stone on the Niagara Peninsula at Fort Erie, Cayuga, Hagersville, and Dunville. Los Angeles Abrasion Test: 17-35% loss; Absorption: 1.4%. Shaly parts are unsuitable for aggregate due to high soundness losses.

BOBCAYGEON FORMATION (MIDDLE ORDOVICIAN)

Composition: Compact, homogeneous, medium to thin-bedded, fine-grained limestone with some argillaceous and shaly partings. Thickness: The lower unit is 40 to 72 feet (12 to 22 m) thick in the east and the remainder of the formation is 40 feet (12 m). Uses: Quarried at Kirkfield and Marysville for crushed stone. The Bobcaygeon Formation has consistently acceptable quality for granular base course materials and concrete.

BOIS BLANC FORMATION (LOWER-MIDDLE DEVONIAN)

Composition: Brownish grey, medium-crystalline, medium- to thin-bedded, cherty limestone, commonly fossiliferous. Limestone may be silty or sandy in places. Thickness: 9 to 200 feet (3 to 61 m). Uses: Quarried at Hagersville, Cayuga, and Port Colborne for crushed stone. High chert content makes much of the material unsuitable for concrete aggregate. Los Angeles Abrasion Test: 14-28% loss; Soundness Test: 4-10% loss; Absorption: 0.7-2.0%.

DUNDEE FORMATION (MIDDLE DEVONIAN)

Composition: Fine- to medium-crystalline, brownish grey, medium- to thick-bedded, dolomitic limestone with shaly partings, sandy layers, and chert in some areas. Thickness: 60 to 160 feet (18 to 49 m). Uses: Quarried near Port Dover and Pelee Island for crushed stone.

Used at St. Marys for portland cement. Los Angeles Abrasion Test: 22-32% loss; Absorption: 0-4%.

GULL RIVER FORMATION (MIDDLE ORDOVICIAN)

Composition: Member A: thin- to thick-bedded, interbedded, grey argillaceous limestone and buff to green dolostone with a maximum thickness of 60 feet (18 m). Members B and C are dense, aphanitic limestones with argillaceous dolostone interbeds. Uses: Quarried at Kirkfield, Victoria County, and Uhthoff for crushed stone. The product is generally fresh and compact with good cubic-shaped factor, low clay content, low absorption, and low soundness losses. Smooth particle surfaces may cause adhesion problems for asphalt. There is some alkali reactivity in a few of the layers.

LOCKPORT AND AMABEL FORMATIONS (MIDDLE SILURIAN)

Composition: Amabel Formation (Waterdown to the Bruce Peninsula): massive, fine-crystalline dolostone, with reef facies, dolostone near Georgetown. Lockport Formation (lateral facies equivalent to the Amabel Formation from Waterdown to Niagara Falls): thin- to massive-bedded, fine- to medium-grained dolostone. Thickness: Amabel Formation: maximum observed thickness of 84 feet (26 m). Lockport Formation: up to 130 feet (40 m). Uses: The Lockport and Amabel Formations have been used to produce lime, crushed stone, concrete aggregate and building stone throughout their area of occurrence, and are a resource of provincial significance. Los Angeles Abrasion Test: 21-35% loss; Soundness Test: 2.0% loss; Absorption: 0.4-1.6%.

ONONDAGA FORMATION (MIDDLE DEVONIAN)

(Equivalent to the Detroit River Group, with a textural change) Composition: Edgecliff Member: medium-bedded, fine- to medium-grained, dark grey cherty limestone with an estimated thickness of 25 to 30 feet (8 to 9 m). Clarence Member: massive-bedded, dark grey brown, fine-grained, very cherty limestone having an estimated thickness of 26 feet (8 m). Moorehouse Member: medium-bedded, dark grey brown or purplish brown, fine- to coarse-grained, variably cherty limestone with an estimated thickness of 15 to 25 feet (5 to 8 m). Uses: Quarried for crushed stone on the Niagara Peninsula at Welland and Port Colborne. High chert content makes much of the material unsuitable for concrete aggregate.

OTTAWA FORMATION (MIDDLE ORDOVICIAN)

Composition: Lower Phase (Lowville and Pamela Beds): shale, some sandstone and dolostone. Thickness: 100 feet (30 m). Middle Phase (Hull, Rockland, and Leray Beds): pure, thick-bedded, crystalline limestone. Thickness: 150 feet (46 m) near Ottawa. Upper Phase (Cobourg and Sherman Fall Beds): pure and impure crystalline limestone with few to numerous shaly partings, 450 to 475 feet (137 to 145 m) thick near Ottawa. Uses: The Leray, Rockland, and Hull Beds have been quarried extensively for crushed stone and for building stone. In addition, the Hull Beds are an excellent source of lime for cement production and agricultural uses.

OXFORD FORMATION (LOWER ORDOVICIAN)

Composition: Medium- to thick-bedded, grey dolostone, with some shaly partings. Thickness: 240 feet (73 m). Uses: Quarried for crushed stone (road and concrete aggregate) at Ottawa, Brockville, and Smiths Falls.

BEDROCK SUITABLE FOR LIME PRODUCTION AND OTHER CHEMICAL USES

DETROIT RIVER GROUP (MIDDLE DEVONIAN)

(Equivalent to the Onondaga Formation in the Niagara Peninsula, with a textural change) Composition: Near Beachville, the group consists of medium- to micro-crystalline, medium-bedded, high-purity limestone. It grades northwards near St. Marys to soft, evenly bedded, fine-grained dolostone with bituminous laminae. Massive, porous, reef facies material also occurs to the north (Formosa Reef Limestone). Thickness: 100 feet (30 m) at Beachville, 350 feet (107 m) at Clinton. Uses: The most important source of high-purity limestone in Ontario is the Lucas Formation of the Detroit River Group at Beachville. Detroit River limestone produces 80% of Ontario's cement. Its dolomitic reefal facies is also important for lime production to the north. It is generally unsuitable for crushed stone. The Anderdon Member of the Lucas Formation is quarried at Amherstburg for crushed stone.

GRENVILLE MARBLE (PRECAMBRIAN)

Composition: Recrystallized white limestone and dolostone, fine- to coarse-grained, usually of high chemical purity. Uses: Lime production, but also in small amounts for terrazzo chips, poultry grit, decorative stone, and building stone.

GUELPH FORMATION (MIDDLE SILURIAN)

Composition: Aphanitic to medium-crystalline, thick-bedded, soft, porous dolostone, characterized in places by extensive vuggy, porous reefal facies dolostone of high chemical purity. The Guelph Formation and the underlying Amabel Formation have a combined thickness of 200 feet (61 m) on the Niagara Peninsula and more than 400 feet (122 m) on the Bruce Peninsula. Uses: The main use is for dolomitic lime in the construction industry. The formation is quarried near Hamilton and Guelph.

LINDSAY FORMATION (MIDDLE ORDOVICIAN)

Composition: Lower Member: fine-crystalline, rubbly, nodular-weathering limestone. Upper Member: grey calcareous claystone with shaly partings and bioclastic layers. The rock is "soft" and weathers to rubble. Both members are characterized by low dolomite content and by numerous clayey partings. Uses: Quarried at Picton, Ogden Point and Bowmanville for cement. The formation is generally unsuitable for crushed stone, concrete aggregate, or granular base course.

VERULAM FORMATION (MIDDLE ORDOVICIAN)

Composition: Fossiliferous, pure to argillaceous limestone and interbedded calcareous shale. The rock is not resistant to erosion and commonly weathers to rubble. Thickness: 200 to 300 feet (61 to 91 m). Uses: Quarried at Picton, Ogden Point, and Mara Township for cement. The formation is unsuitable for crushed stone due to clay impurities, many clayey interbeds, and low abrasion resistance, high soundness losses and poor freeze and thaw resistance.

BEDROCK SUITABLE FOR BRICK AND TILE MANUFACTURE

GEORGIAN BAY FORMATION (UPPER ORDOVICIAN)

(Formerly known as the Meaford-Dundas and Blue Mountain shales in the Toronto and Bruce Peninsula areas) Composition: Soft, fissile, blue grey shale with limey or sandy lenses in a few places. Thickness: 640 feet (195 m) at Toronto. Uses: Several producers in Metro Toronto and Cooksville produce brick and structural tile. Lightweight aggregate is also produced at Streetsville by heat expansion of the shale.

HAMILTON GROUP (MIDDLE DEVONIAN)

Composition: Grey shale with interbeds of crystalline and cherty limestone. The group has six formations, but only the Arkona is of commercial value. It is a soft, light grey, calcareous shale which is plastic and easily worked when wet. Thickness: 80 to 300 feet (24 to 91 m). Uses: The Arkona Formation is extracted at Thedford and near Arkona for production of drainage tile and brick.

QUEENSTON FORMATION (UPPER ORDOVICIAN)

Composition: Red, thin- to thick-bedded, sandy to argillaceous shale with green mottling and banding. Thickness: 400 to 500 feet (122 to 152 m). Uses: There are several large shale quarries developed in the Queenston Formation in the Toronto-Hamilton region and one at Russell, near Ottawa. All produce brick for construction. The Queenston Formation is the most important source material for brick manufacture in the Province.

BEDROCK SUITABLE FOR OTHER INDUSTRIAL PRODUCTS

NEPEAN (POTSDAM) FORMATION (CAMBRO-ORDOVICIAN)

Composition: Creamy, coarse-grained, silica sandstone. Uses: Quarried throughout its area of outcrop for building stone, decorative stone, abrasives, and for glass making.

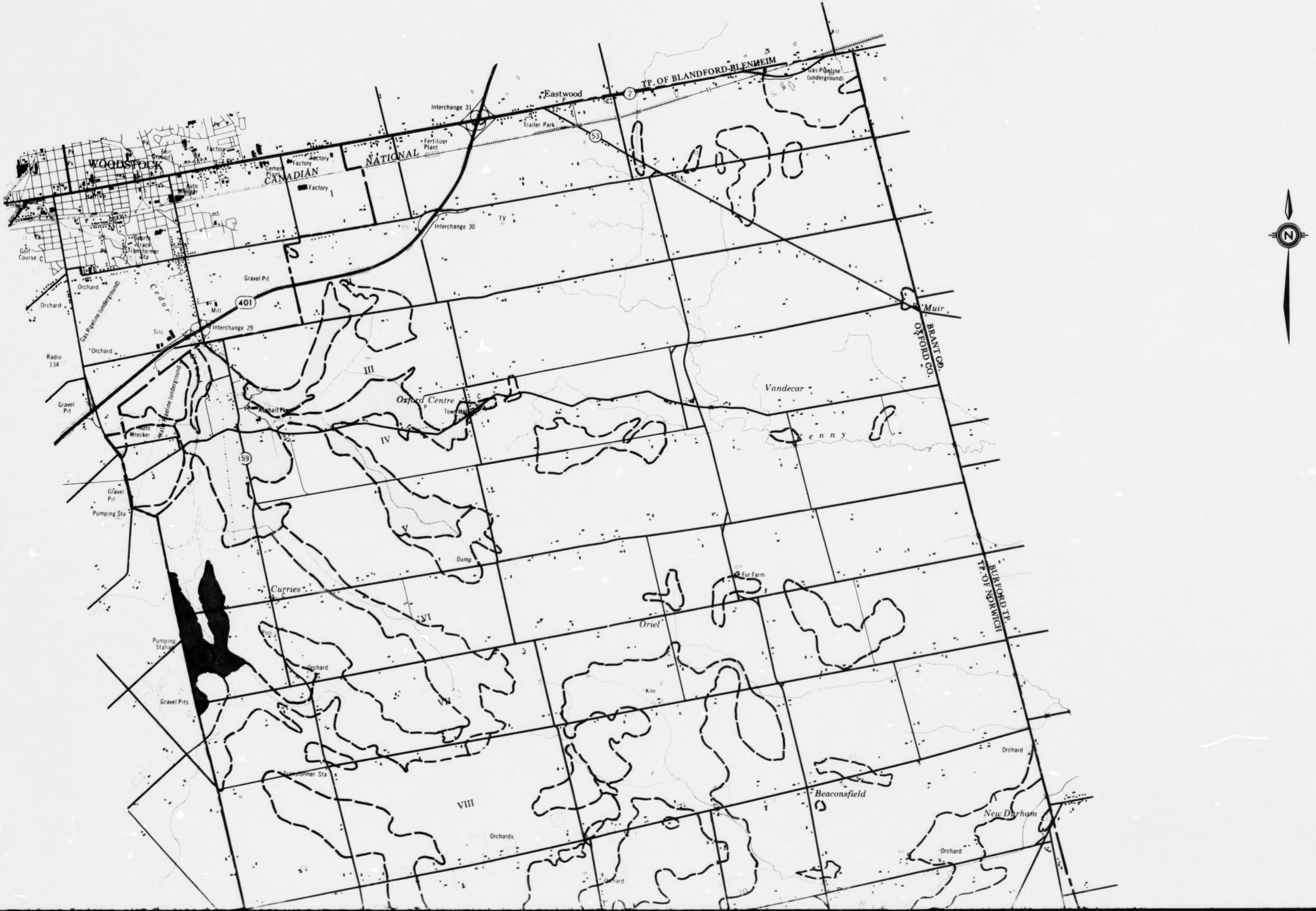
SALINA FORMATION (UPPER SILURIAN)

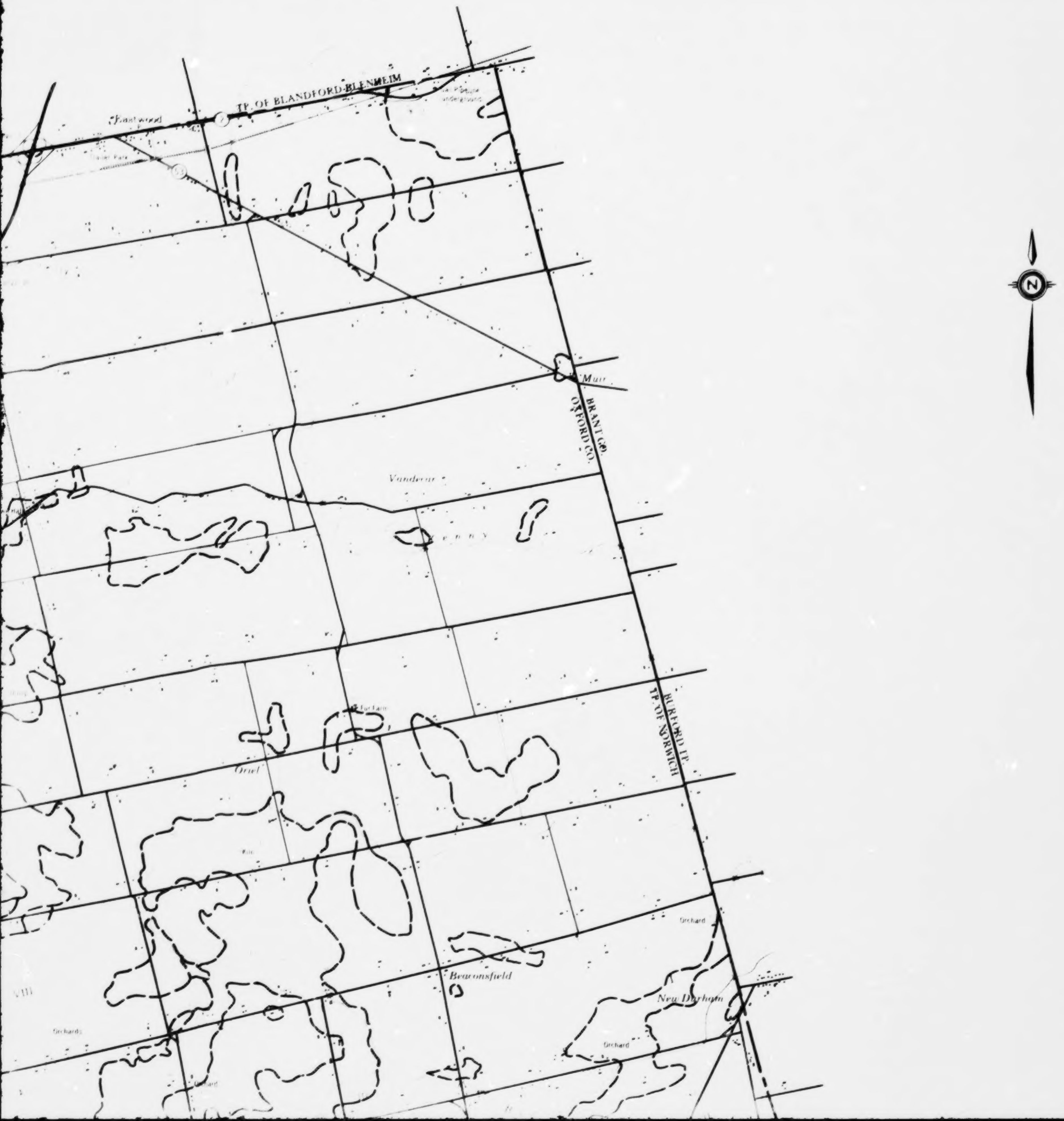
Composition: Grey and red shale, brown dolomite, and, in places, salt, anhydrite, and gypsum.

The formation consists predominantly of evaporite deposits with up to eight members identified. Uses: Gypsum is mined at Hagersville, Caledonia, and Drumbo. Salt is mined at Goderich and is produced from brine wells at Amherstburg, Windsor, and Sarnia.

WHITBY FORMATION (UPPER ORDOVICIAN)

(Formerly known as Collingwood Shale near Toronto) Composition: Brown to black fissile shale. Uses: Quarried at Bowmanville for use in cement production. Testing indicates that the Whitby Formation may produce satisfactory lightweight expanded aggregate.


WOODSTOCK
CANADIAN
NATIONAL
Factory
Cement Plant
Fair Ground
Fertilizer Plant
Auto Wrecker
Interchange 31
Eastwood
2
TP. OF BLANDFORD-BLENHEIM
Gas Pipeline (underground)
Trailer Park
53
I
Interchange 30
TV
Golf Course
Sports Track
Transformer Sta
Orchard
Gravel Pit
Cedar
Gas Pipeline (underground)
401
Mill
Silo
Interchange 29
Radio 134
Muir
BRANT CO.
OXFORD CO.
III
Oxford Centre
Town Hall
Asphalt Plant
Vandecar
Kenny
Water Pipeline (underground)
IV
59
Pumping Sta
V
Dump
Curries
Fur Farm
VI
Oriel
BURFORD TP.
TP. OF NORWICH
Pumping Station
Orchard
VII
Kiln
Gravel Pits
Transformer Sta
VIII
Orchards
Beaconsfield
New Durham
Orchard
N


TP. OF BLANDFORD-BLENHEIM
Eastwood
Muir
BRANT CO.
OXFORD CO.
Vandecar
Kenny
McLean
Oriel
BURFORD TP.
TP. OF NORWICH
Orchard
Beaconsfield
New Durham
Orchards
N

Ontario

Ministry of Natural Resources

Hon. Alan W. Pope
Minister

W. T. Foster
Deputy Minister

ONTARIO GEOLOGICAL SURVEY
AGGREGATE RESOURCES INVENTORY

TOWNSHIP OF NORWICH

OXFORD COUNTY

MAP 2
SELECTED SAND AND GRAVEL RESOURCE AREAS

Scale 1:50 000

Mile 1 — 0 — 1 Mile
Metres 1000 — 0 — 1 Kilometre

NTS Reference: **40 I/15** **40 P/2**

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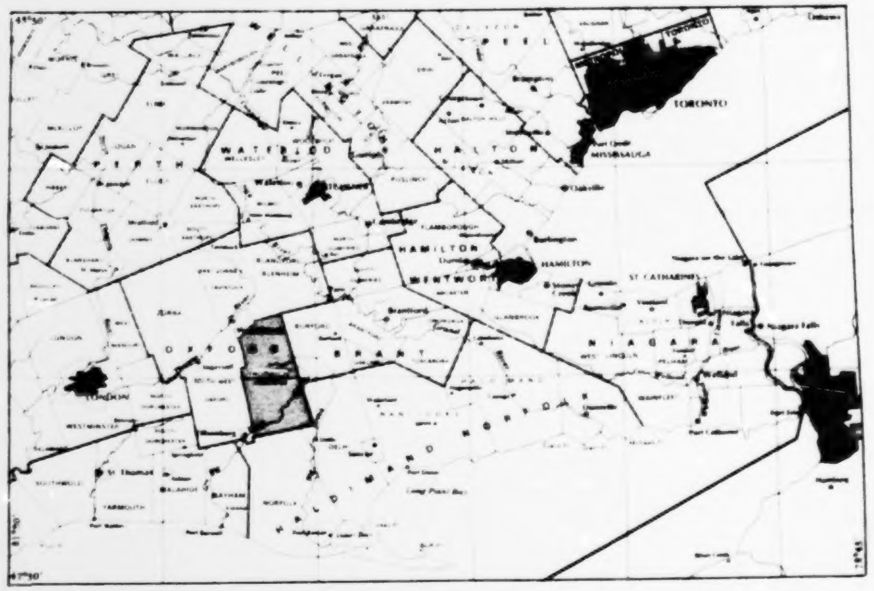

PERTH
WATERLOO
HALTON
PEEL
TORONTO
MISSISSAUGA
HAMILTON
WENTWORTH
ST. CATHARINES
NIAGARA
OXFORD
BRANT
HALDIMAND-NORFOLK
LONDON

SYMBOLS

(Some symbols may not apply to this map.)

— — — — Geological and aggregate thickness boundary.

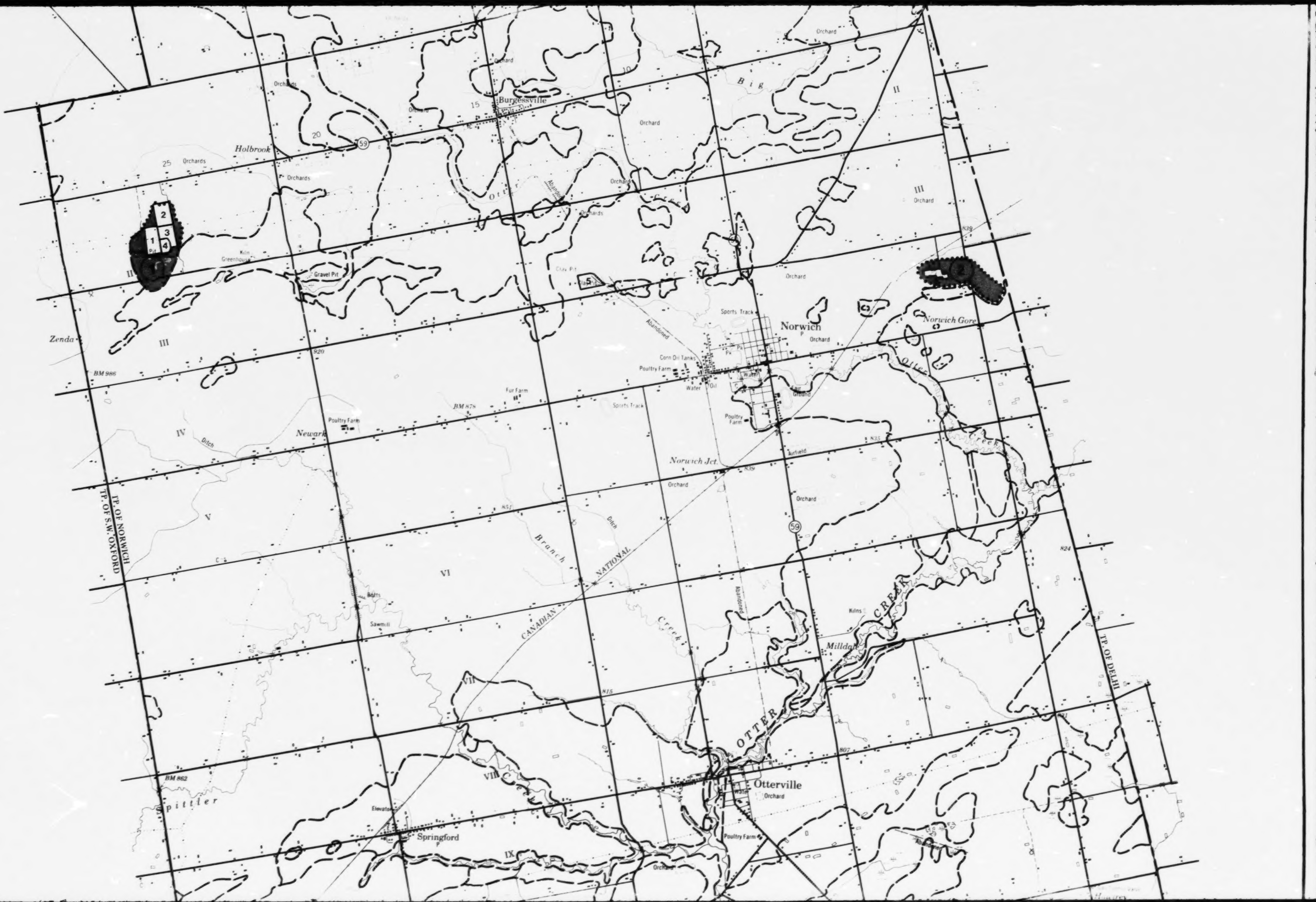
•••••••••••••••••• Buried geological and aggregate thickness boundary.

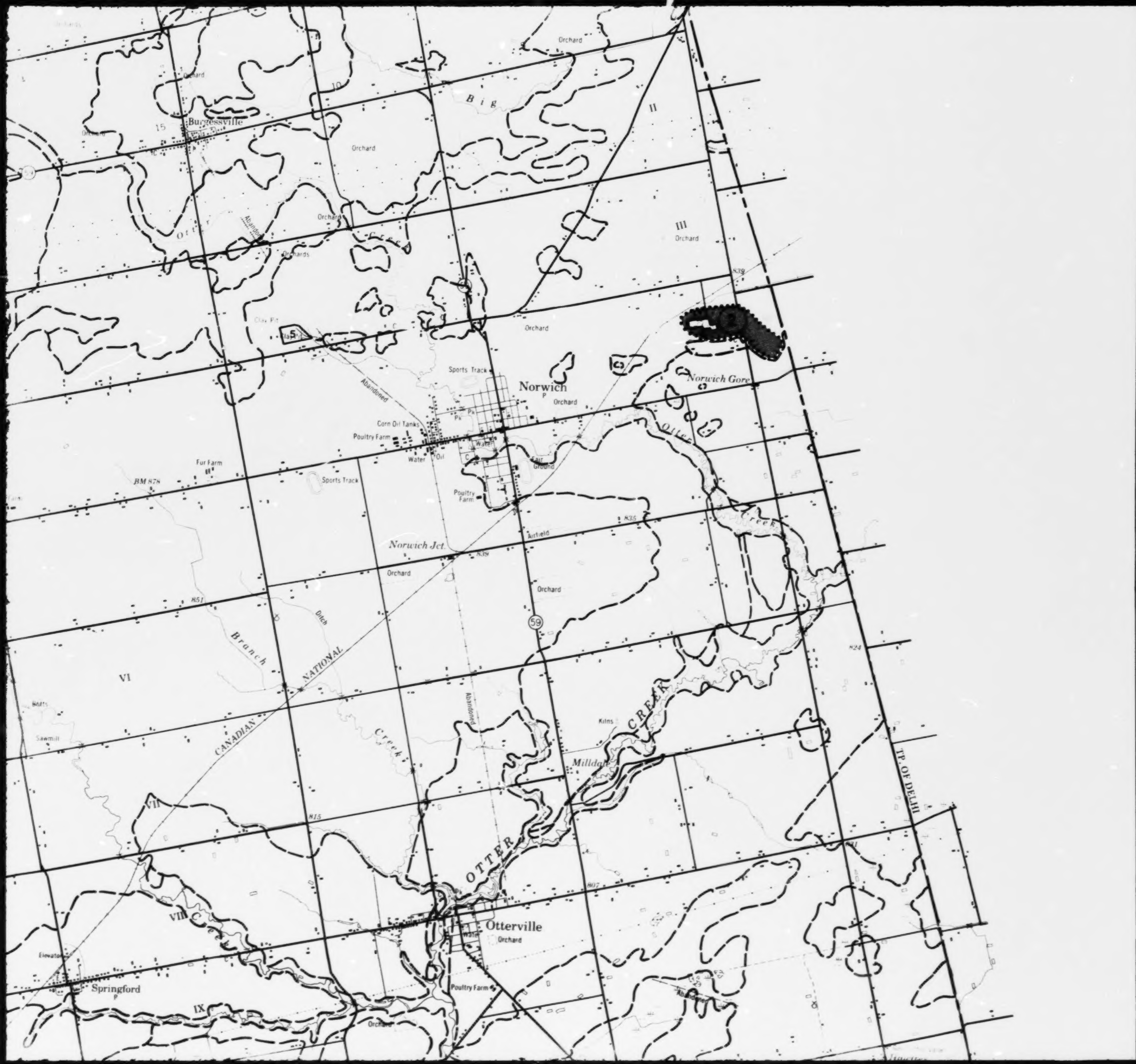
——— – ——— Municipal boundary.

■ Selected sand and gravel resource area; Primary significance; Deposit number: see Table 3.

□ Selected sand and gravel resource area; Secondary significance.

□ Selected sand and gravel resource area; Tertiary significance.


Orchard
Orchards
Orchard
Burgessville
15
10
20
59
Big
Orchard
II
Holbrook
25
Orchards
Orchards
Otter
Creek
Abandoned
Orchard
Orchards
III
Orchard
839
2
1
3
4
Pit
Kiln
Greenhouse
Gravel Pit
Clay Pit
5
II
Orchard
Sports Track
Norwich
Orchard
Norwich Gore
Zenda
III
920
Abandoned
Corn Oil Tanks
Poultry Farm
Water
Oil
BM 986
Fur Farm
BM 878
Poultry Farm
Newark
Sports Track
Fair Ground
Poultry Farm
Otter
IV
Ditch
835
Airfield
Norwich Jct.
839
Orchard
Orchard
Creek
V
851
Branch
Ditch
59
TP. OF NORWICH
TP. OF S.W. OXFORD
CANADIAN
NATIONAL
VI
824
Abandoned
Creek
Kilns
CREEK
Bolts
Sawmill
Milldale
TP. OF DELHI
VII
815
OTTER
807
BM 862
VIII
Creek
Elevator
Otterville
Orchard
Springford
Spittler
IX
Poultry Farm
Orchard



Burgessville
15
10
Big
Otter
Creek
II
III
Orchard
Orchards
Abandoned
Clay Pit
5
2
839
Sports Track
Norwich
Norwich Gore
Otter
Creek
Corn Oil Tanks
Poultry Farm
Water
Oil
Fair Ground
Fur Farm
BM 878
Poultry Farm
835
Airfield
Norwich Jct.
851
59
824
Branch
Ditch
NATIONAL
CANADIAN
VI
Bells
Sawmill
Abandoned
Creek
Kilns
CREEK
Milldale
VII
815
OTTER
807
VIII
Otterville
Water
Elevator
Springford
IX
Poultry Farm
TP. OF DELHI

②	Selected sand and gravel resource area; Primary significance; Deposit number: see Table 3.
▢	Selected sand and gravel resource area; Secondary significance.
▢	Selected sand and gravel resource area; Tertiary significance.
2	Licenced property boundary; Property number: see Table 2.
● 3	Unlicenced sand or gravel pit*; Property number: see Table 2. *Abandoned pit or wayside pit operating on demand under authority of a permit.

SOURCES OF INFORMATION

Base map by Surveys and Mapping Branch, Ontario Ministry of Natural Resources.

Licence data from District and Regional Offices, Ontario Ministry of Natural Resources.

Aggregate suitability data from the Engineering Materials Office, Ontario Ministry of Transportation and Communications.

Geology by: P. J. Barnett, 1980.
W.R. Cowan, 1975.

Compilation and Drafting by: Staff of the Aggregate Assessment Office.

This map is to accompany O.G.S. Aggregate Resources Inventory Paper 66.

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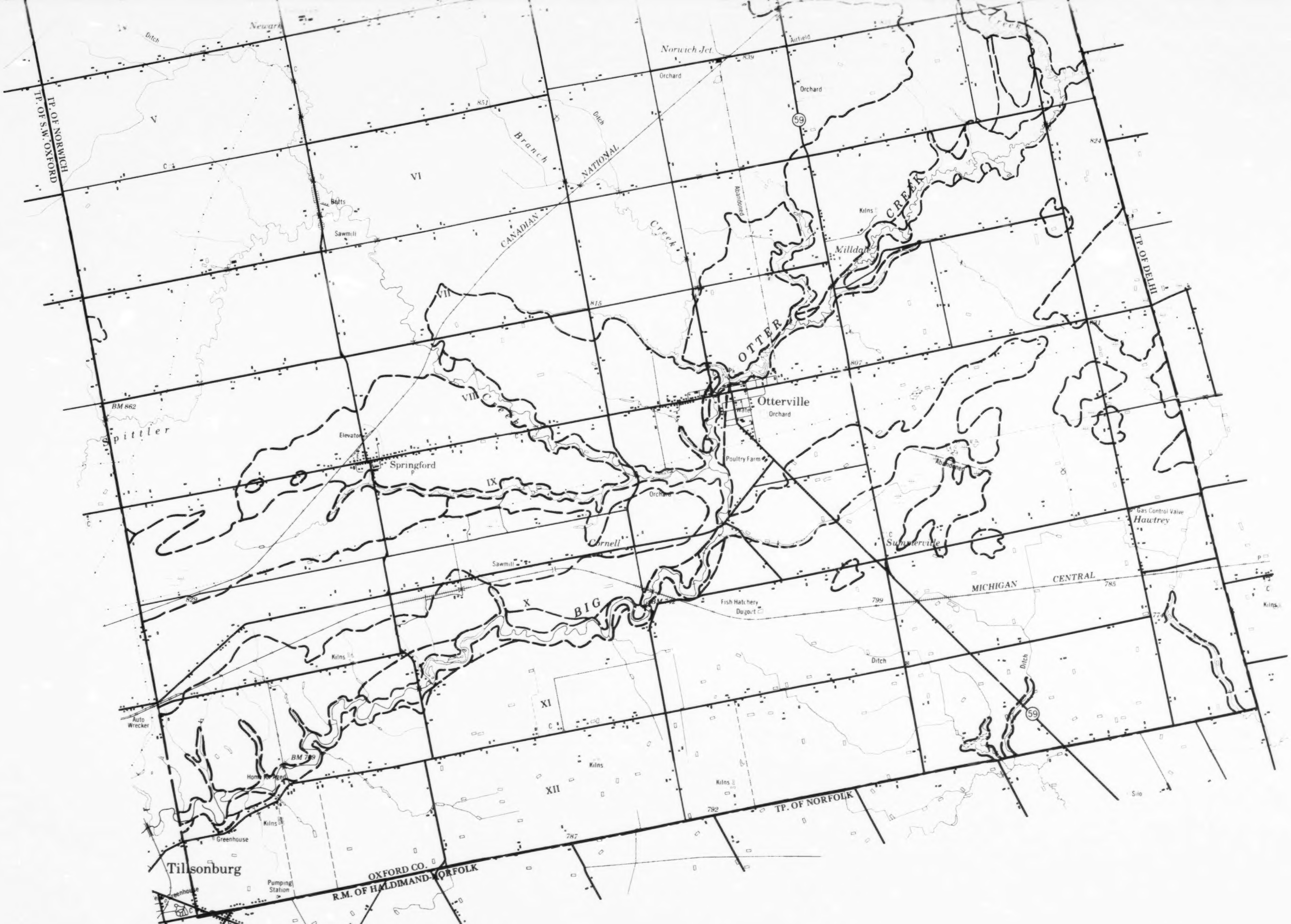
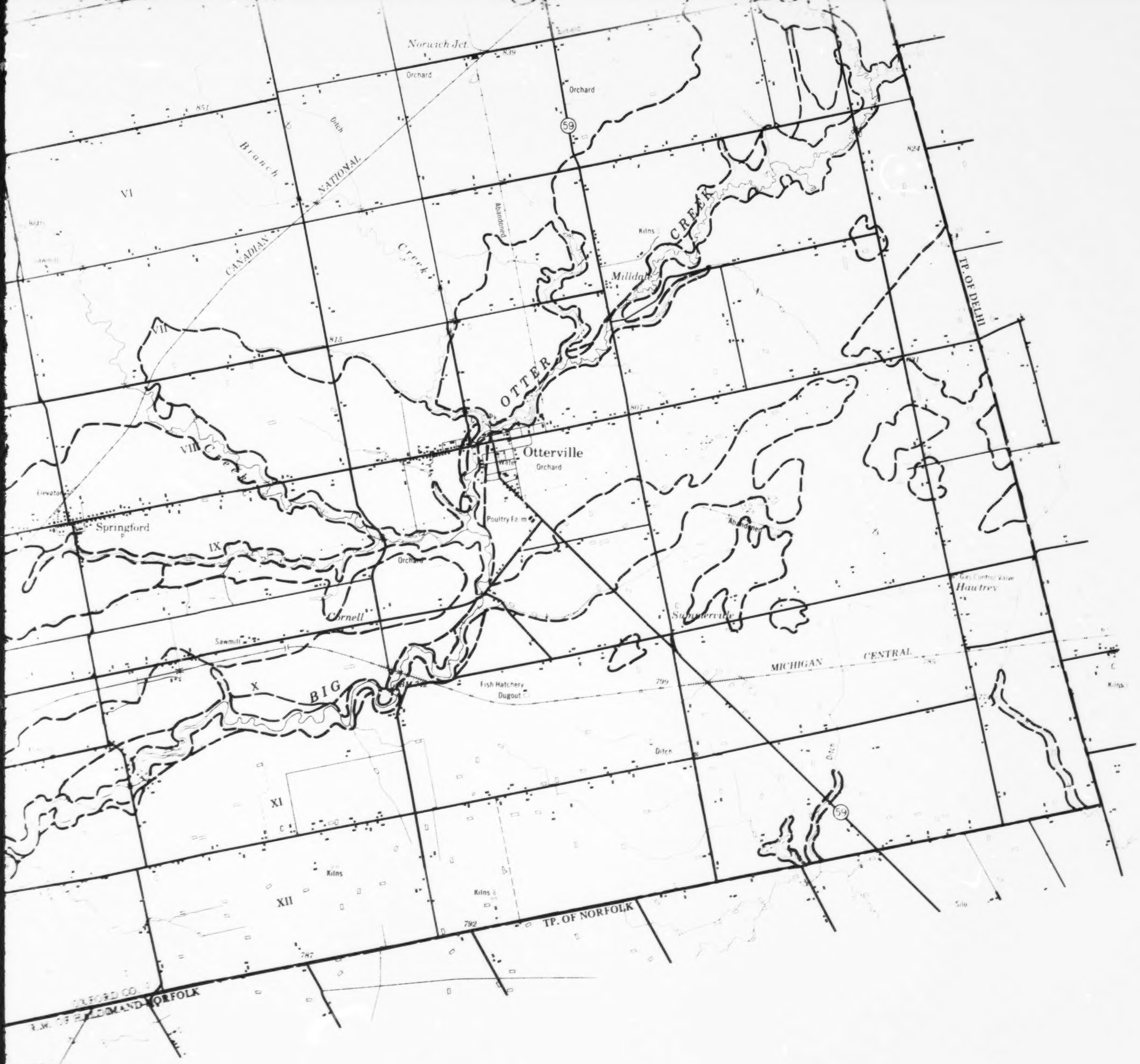
Issued 1982.


Newark
Ditch
Norwich Jct.
839
Airfield
Orchard
Orchard
TP. OF NORWICH
TP. OF S.W. OXFORD
V
851
Branch
Ditch
59
C
VI
CANADIAN
NATIONAL
Creek
Bolts
Sawmill
Abandoned
Creek
Kilns
CREEK
Milldale
824
TP. OF DELHI
VII
815
OTTER
831
807
BM 862
Spittler
VIII
Creek
Otterville
Orchard
Elevator
Springford
Poultry Farm
Abandoned
IX
Orchard
Gas Control Valve
Hawtrey
C
Cornell
Summerville
Sawmill
MICHIGAN
CENTRAL
785
X
BIG
Fish Hatchery
Dugout
799
Kilns
829
Kilns
Ditch
Ditch
XI
59
Auto Wrecker
BM 769
Home for Aged
Kilns
XII
Kilns
792
TP. OF NORFOLK
Silo
Greenhouse
Kilns
787
Tillsonburg
OXFORD CO.
R.M. OF HALDIMAND-NORFOLK
Pumping Station
Greenhouse
Gravel Pit
Motel


Norwich Jct.
Orchard
Orchard
59
Branch
NATIONAL
CANADIAN
Ditch
VI
Abandoned
Creek
Kilns
CREEK
Milldale
OTTER
TP. OF DELHI
VII
815
824
807
VIII
Otterville
Orchard
Water
Elevator
Springford
IX
Poultry Farm
Orchard
Abandoned
Gas Control Valve
Hawtrey
Cornell
Summerville
Sawmill
MICHIGAN
CENTRAL
X
BIG
Fish Hatchery
Dugout
799
Kilns
Ditch
Ditch
XI
59
Kilns
XII
Kilns
792
TP. OF NORFOLK
787
Silo
OXFORD CO.
R.M. OF HALDIMAND-NORFOLK

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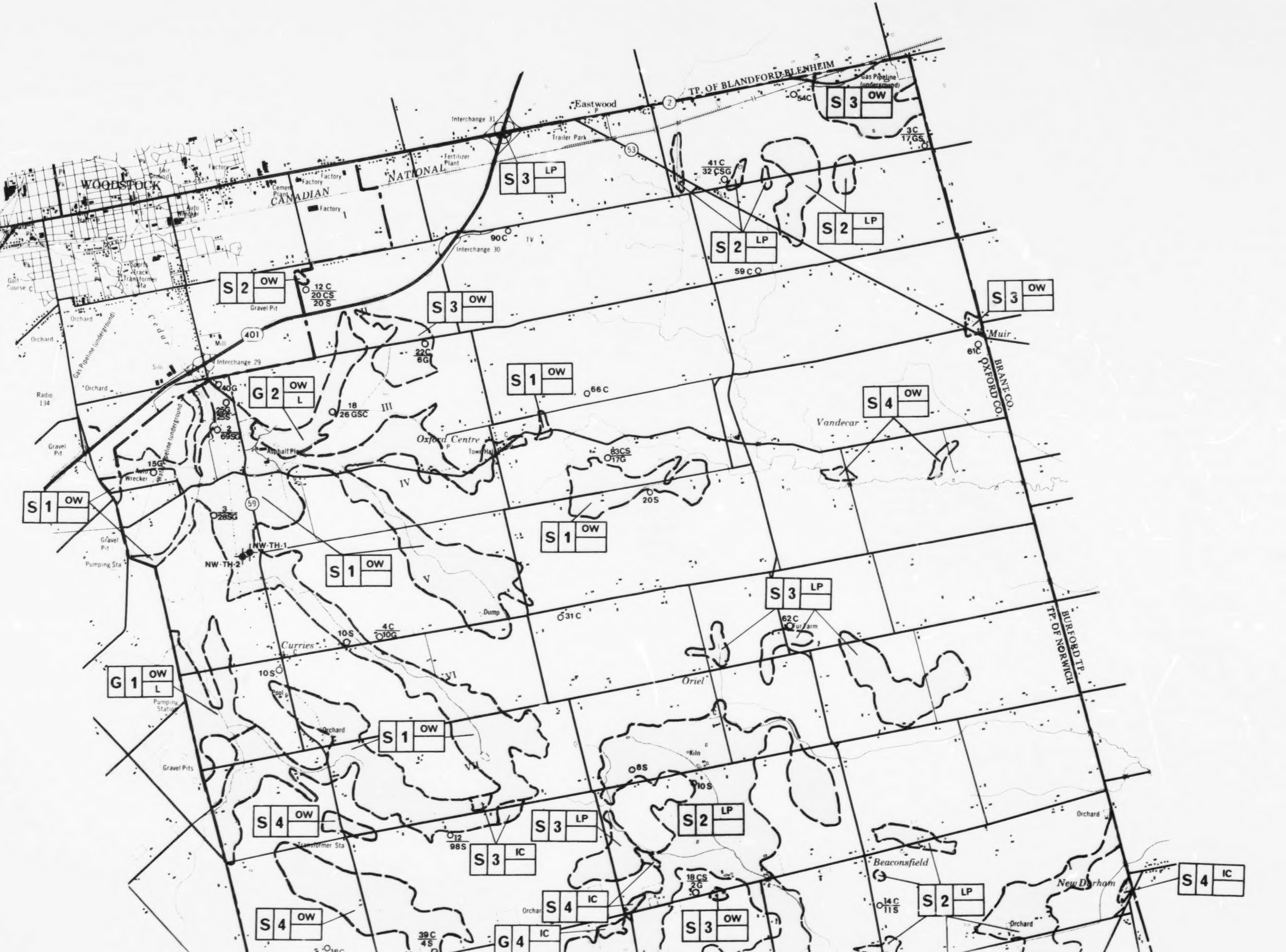
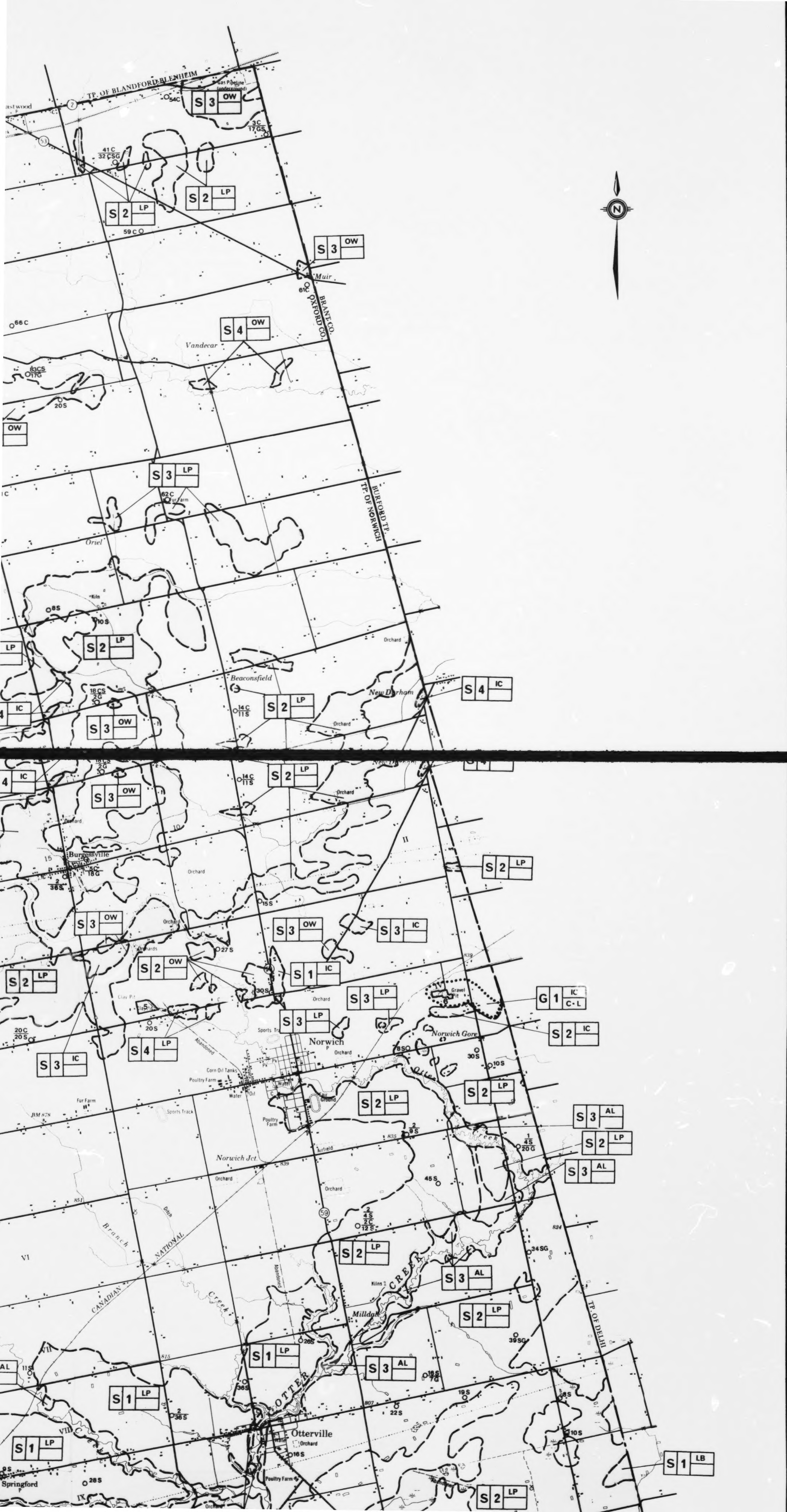
Issued 1982.


WOODSTOCK
CANADIAN
NATIONAL
TP. OF BLANDFORD-BLENHEIM
Eastwood
Interchange 31
Interchange 30
Interchange 29
Trailer Park
Fertilizer Plant
Factory
Cement Plant
Fair Ground
Auto Wrecker
Sports Track
Transformer Sta
Golf Course
Gravel Pit
Orchard
Cedar
Mill
Silo
Radio 134
Gas Pipeline (underground)
Water Pipeline (underground)
Asphalt Plant
Pumping Sta
Pumping Station
Gravel Pits
Oxford Centre
Town Hall
Dump
Curries
Pool
Oriel
Kiln
Fur Farm
Vandecar
Muir
BRANT CO.
OXFORD CO.
BURFORD TP.
TP. OF NORWICH
Beaconsfield
New Durham
2
53
401
59
S 3 OW
S 3 LP
S 2 LP
S 2 OW
S 3 OW
S 1 OW
G 2 OW L
S 4 OW
S 1 OW
S 1 OW
S 3 LP
G 1 OW L
S 1 OW
S 4 OW
S 3 LP
S 2 LP
S 3 IC
S 4 IC
S 4 OW
G 4 IC
S 3 OW
S 2 LP
S 4 IC
III
IV
V
VI
VII
54C
3C 17GS
41 C 32 CSG
59 C
61C
90 C
12 C 20 CS 20 S
22C 6G
40G
22C 25S
2 69SG
18 26 GSC
66 C
83CS 17G
20S
15G
3 28SG
NW-TH-1
NW-TH-2
31 C
62C
4C 10G
10S
10S
8S
10S
12 98S
18CS 2G
14 C 11 S
39 C 4S
18C


TP. OF BLANDFORD-BLENHEIM
Gas Pipeline (underground)
S 3 OW
S 2 LP
S 3 OW
Muir
BRANT CO.
OXFORD CO.
S 4 OW
Vandecar
TP. OF NORWICH
BURFORD TP.
S 3 LP
Oriel
S 2 LP
Beaconsfield
S 2 LP
New Durham
S 4 IC
S 3 OW
Burgessville
S 2 LP
S 3 OW
S 3 OW
S 3 IC
S 2 OW
S 1 IC
S 3 LP
G 1 IC C·L
S 3 LP
Norwich Gore
S 2 IC
Norwich
S 4 LP
S 3 IC
S 2 LP
S 2 LP
S 3 AL
S 2 LP
S 3 AL
Norwich Jct.
CANADIAN NATIONAL
OTTER CREEK
S 2 LP
S 3 AL
Milldale
S 2 LP
S 1 LP
S 3 AL
S 1 LP
Otterville
S 1 LP
Springford
S 1 LB
S 2 LP
TP. OF DELHI
N

Ontario

Ministry of Natural Resources

Hon. Alan W. Pope
Minister

W.T. Foster
Deputy Minister

ONTARIO GEOLOGICAL SURVEY
AGGREGATE RESOURCES INVENTORY

TOWNSHIP OF NORWICH

OXFORD COUNTY

MAP 1
DISTRIBUTION OF SAND AND GRAVEL DEPOSITS

Scale 1:50 000

Mile 1 0 1 Mile

Metres 1000 0 1 Kilometre

NTS Reference: **40 I/15** **40 P/2**

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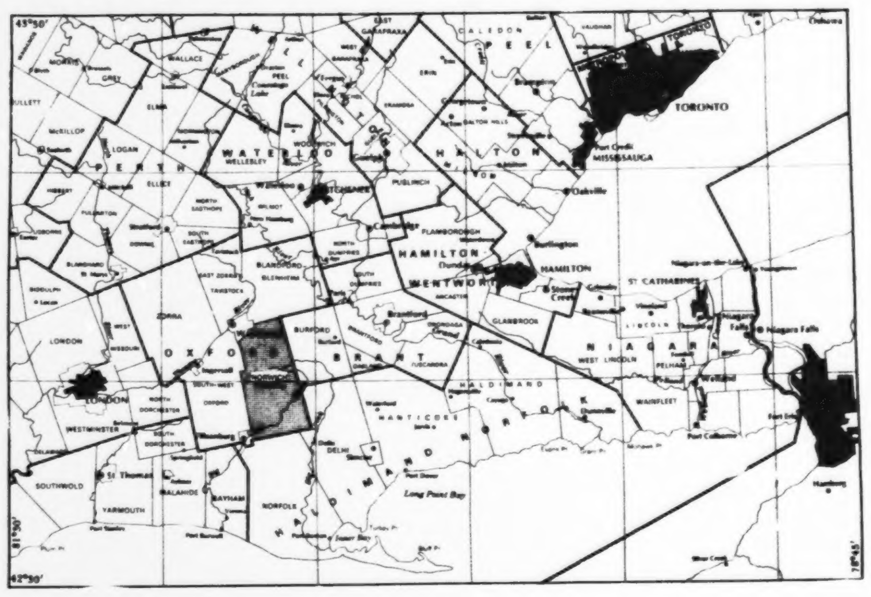

PEEL
TORONTO
WATERLOO
PERTH
HALTON
HAMILTON
WENTWORTH
NIAGARA
OXFORD
BRANT
LONDON
NORFOLK
HALDIMAND
Long Point Bay
43°50'
42°30'
81°30'
78°45'

SYMBOLS

(Some symbols may not apply to this map.)

Geological and aggregate thickness boundary. Shading indicates deposit area.

Buried geological and aggregate thickness boundary. Shading indicates deposit area.

Municipal boundary.

2 Licenced property boundary; Property number: see Table 2.

● 3 Unlicenced sand or gravel pit*; Property number: see Table 2.
*Abandoned pit or wayside pit operating on demand

2 Licenced property boundary; Property number: see Table 2.

● 3 Unlicenced sand or gravel pit*; Property number: see Table 2.
*Abandoned pit or wayside pit operating on demand under authority of a permit.

NW·TH·2 Selected test hole location; Identification number: see Table 7.

○ 6/23 G Selected drilled water well location; reported thickness of material (in feet); reported type of material (number only - overburden, T - till, G - gravel, S - sand, C - clay, Bk - bedrock).

G 1 IC/C·O Deposit Symbol: see below.

Texture symbol: see below.

DEPOSIT SYMBOL

Gravel Content — G 1 IC/C·O — Geological Type
Thickness Class — Quality Indicator

Deposits are identified by Gravel Content, Thickness Class, Geological Type and Quality Indicator. Gravel content is expressed as a percentage of crushable aggregate material. (Crushable aggregate material is defined as unprocessed gravel containing a minimum of 35% coarse aggregate larger than the # 4 sieve, and also a minimum of 20% larger than 1 inch sieve.) Thickness class is based on potential aggregate tonnage per acre. Type refers to geologic origin. Quality indicator describes objectionable grain size and lithology.

Gravel Content

G	Greater than 35% gravel.
S	Less than 35% gravel.

Thickness Class

Class	Average Thickness in feet (metres)	Tons per acre (Tonnes per hectare)
1	greater than 20 (> 6)	greater than 50,000 (> 112 000)
2	10-20 (3-6)	25,000-50,000 (56 000 - 112 000)
3	5-10 (1.5-3)	12,500 - 25,000 (28 000 - 56 000)
4	less than 5 (< 1.5)	less than 12, 500 (< 28 000)

Geological Type

AL	Older Alluvium	**K**	Kame
E	Esker	**LB**	Lacustrine Beach
EM	End Moraine	**LD**	Lacustrine Delta
IC	Undifferentiated Ice-Contact Stratified Drift	**LP**	Lacustrine Plain
		OW	Outwash
ICT	Ice-Contact Terrace	**WD**	Windblown Forms

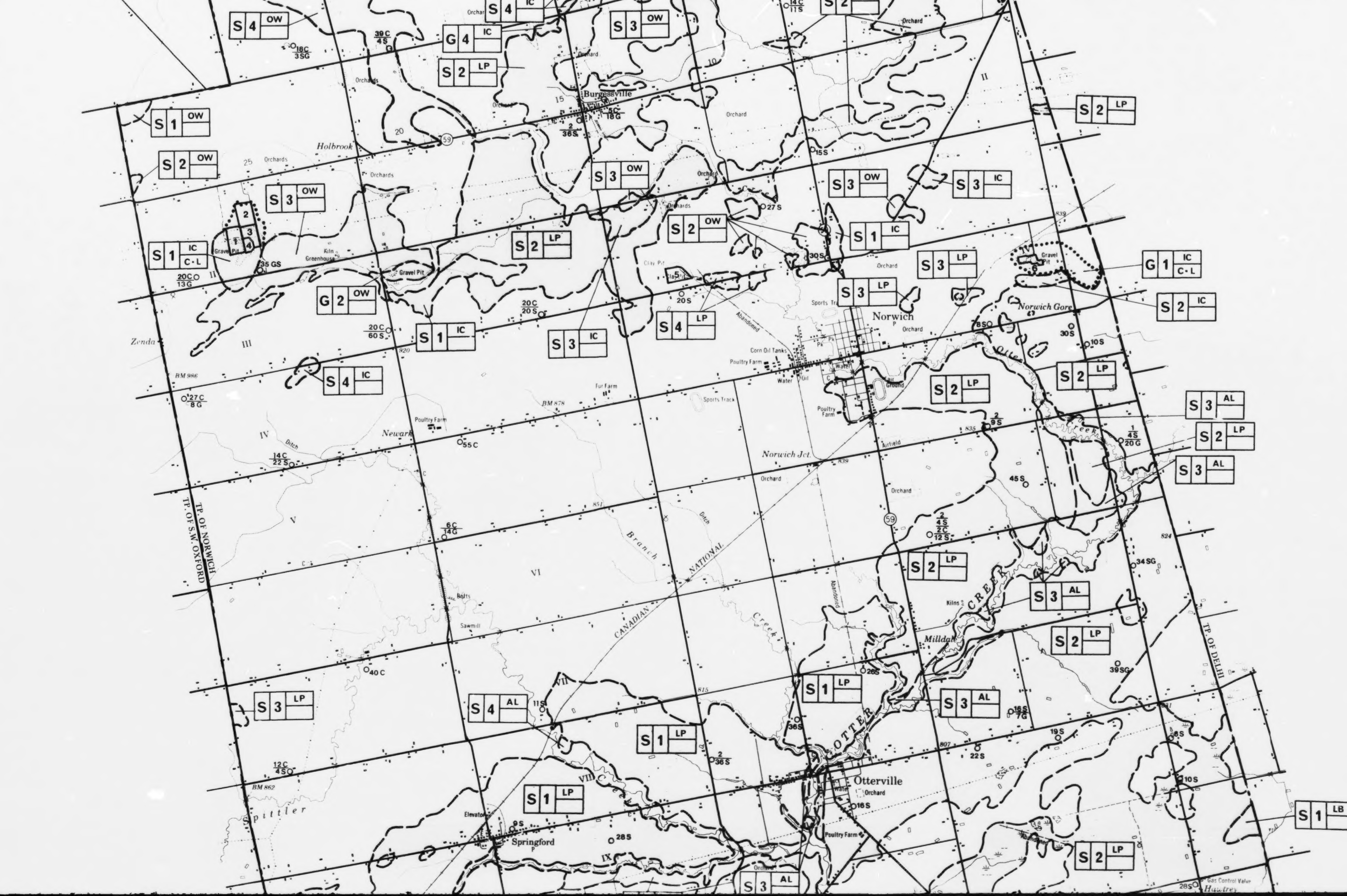
(see Appendix C for descriptions of Geological Types)

Quality Indicator

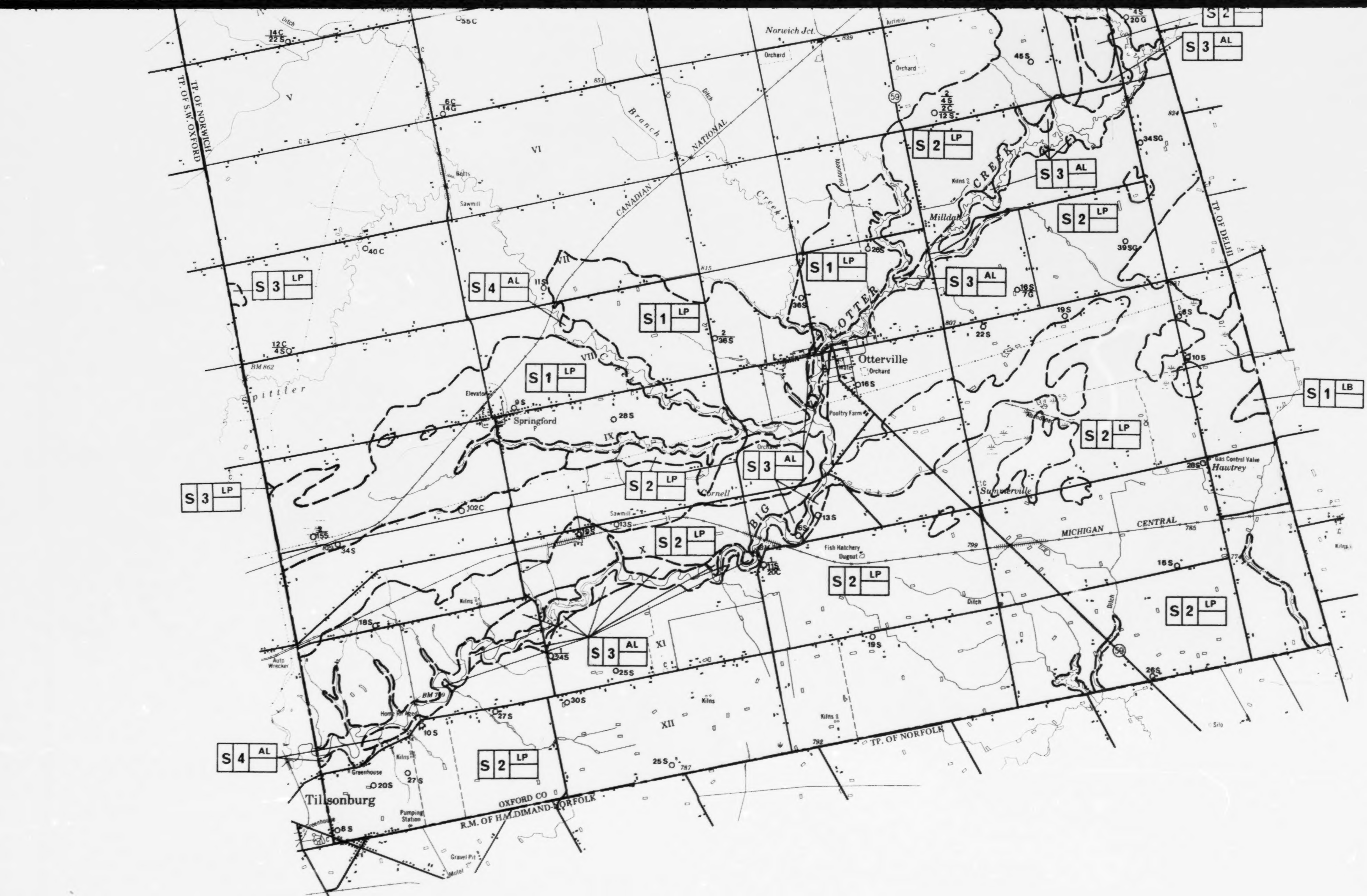
	If blank, no known limitations present.
C	Clay and/or silt (fines) present in objectionable quantities.
L	Deleterious lithologies present.
O	Oversize particles or fragments present in objectionable quantities

TEXTURE SYMBOL

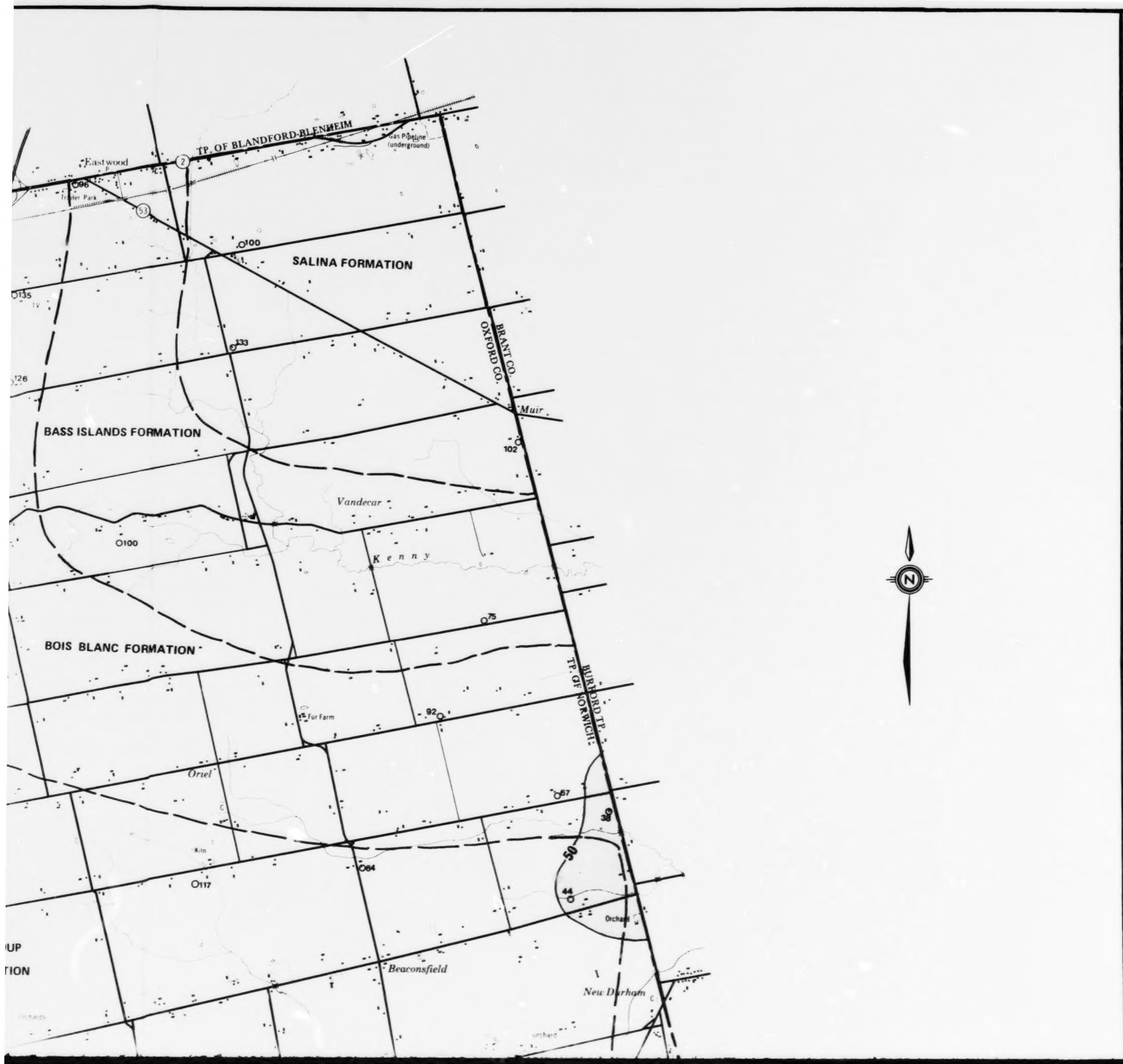
Fines: silt and clay (<.075 mm)

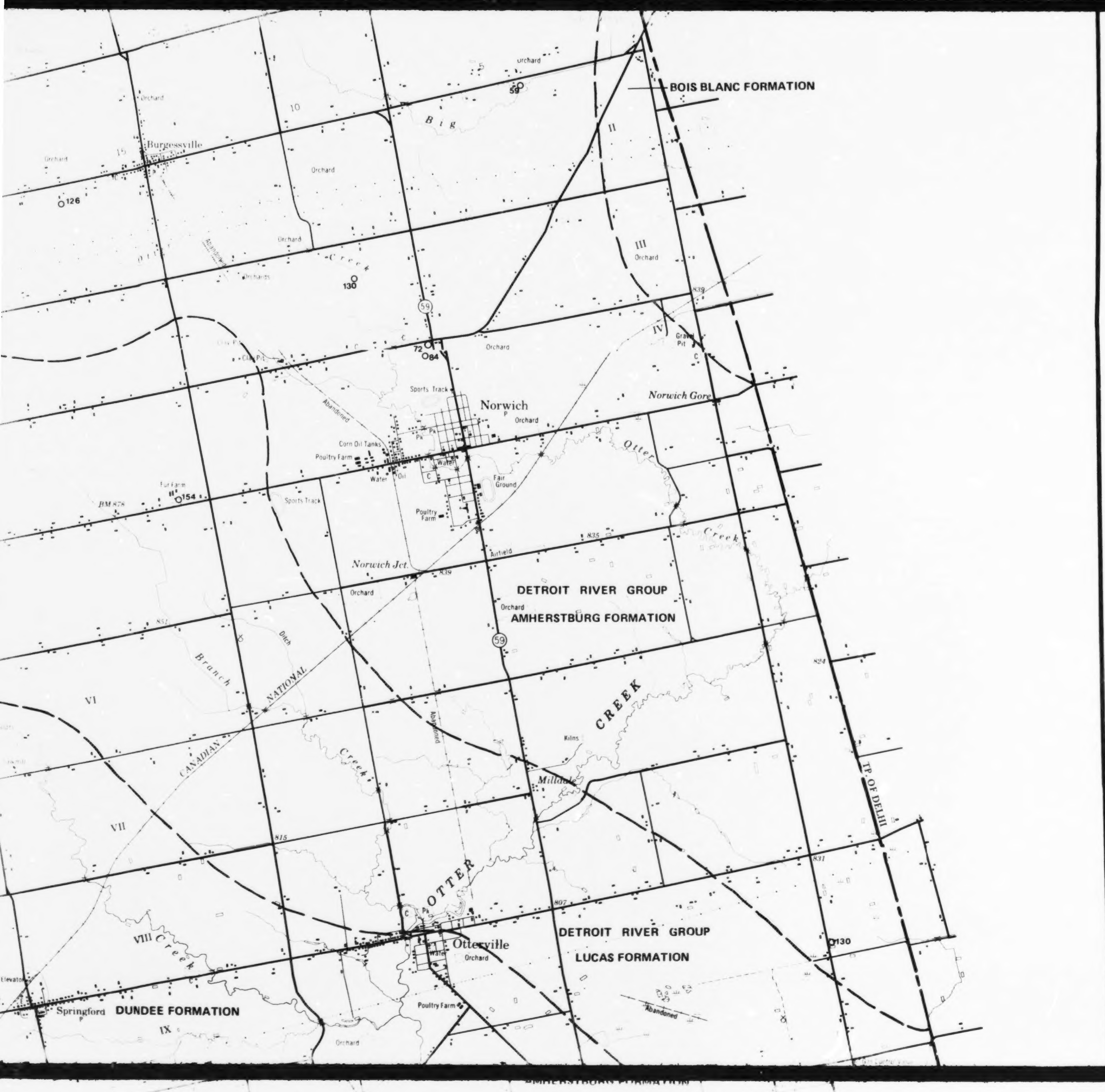


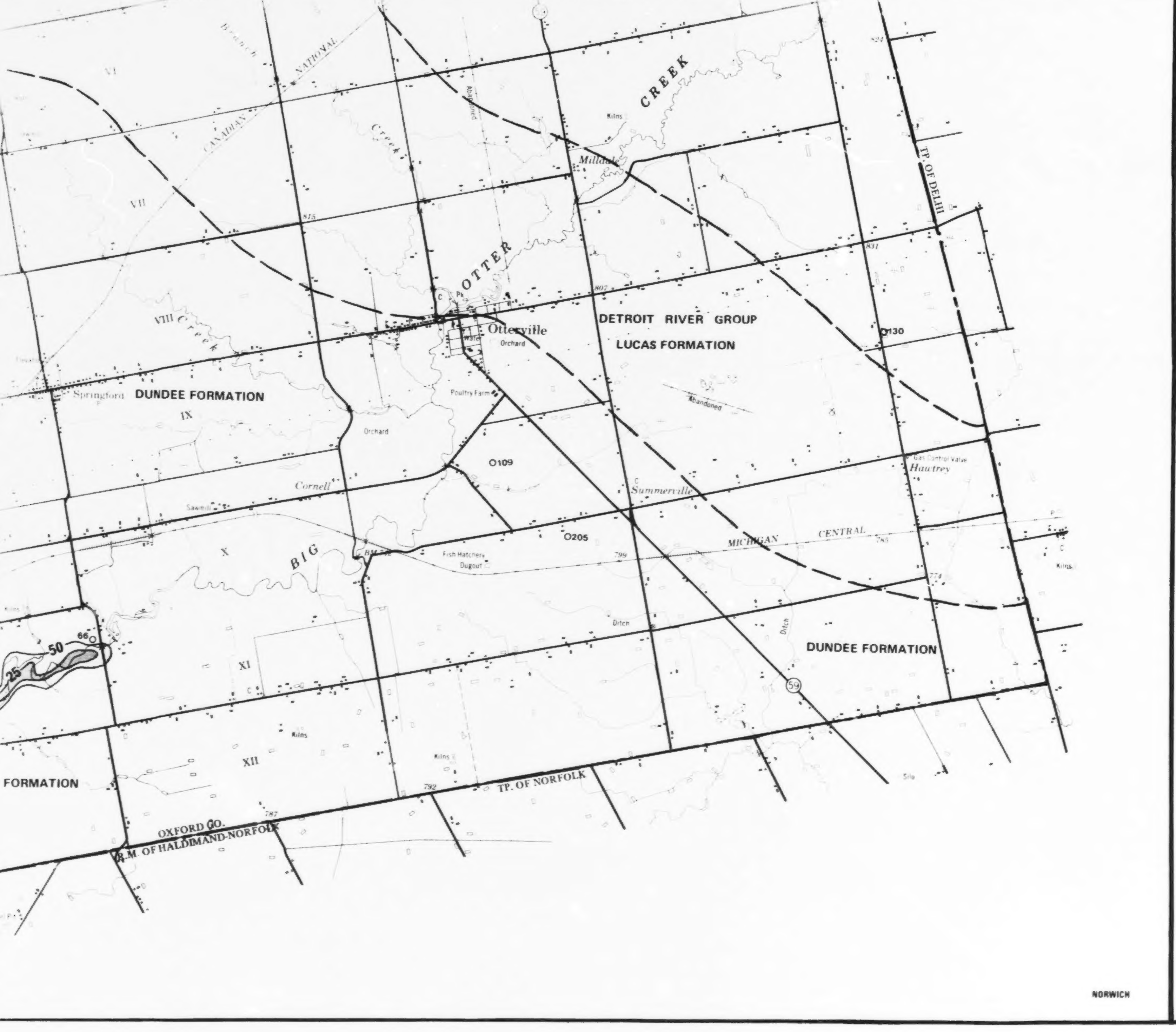
Burgessville
Holbrook
Zenda
Newark
Norwich
Norwich Gore
Norwich Jct.
Otterville
Springford
Milldale
Hawtrey
Spittler
TP. OF NORWICH
TP. OF S.W. OXFORD
TP. OF DELHI
CANADIAN NATIONAL
OTTER CREEK
Branch Creek
Orchard
Poultry Farm
Gravel Pit
Kiln
Greenhouse
Clay Pit
Sports Track
Fur Farm
Corn Oil Tanks
Sawmill
Elevator
Kilns
Gas Control Valve
Abandoned
S 4 OW
S 4 IC
G 4 IC
S 2 LP
S 3 OW
S 1 OW
S 2 OW
S 3 OW
S 1 IC C·L
G 2 OW
S 1 IC
S 3 IC
S 4 IC
S 2 LP
S 2 OW
S 4 LP
S 3 OW
S 1 IC
S 3 LP
G 1 IC C·L
S 2 IC
S 3 IC
S 2 LP
S 3 AL
S 2 LP
S 3 AL
S 2 LP
S 3 AL
S 2 LP
S 1 LP
S 3 LP
S 4 AL
S 1 LP
S 3 AL
S 1 LP
S 1 LB
S 2 LP
S 3 AL
I
II
III
IV
V
VI
VII
VIII
IX



Norwich Jct.
Otterville
Springford
Milldale
Summerville
Hawtrey
Cornell
Tillsonburg
Spittler
TP. OF NORWICH
TP. OF S.W. OXFORD
TP. OF DELHI
TP. OF NORFOLK
OXFORD CO
R.M. OF HALDIMAND-NORFOLK
CANADIAN NATIONAL
MICHIGAN CENTRAL
OTTER CREEK
BIG
Branch Creek
Fish Hatchery
Dugout
Pumping Station
Auto Wrecker
Greenhouse
Kilns
Sawmill
Elevator
Poultry Farm
Gas Control Valve
Gravel Pit
Motel
Silo
S 2 LP
S 3 AL
S 2 LP
S 3 AL
S 2 LP
S 1 LP
S 3 LP
S 4 AL
S 1 LP
S 3 AL
S 1 LP
S 1 LB
S 2 LP
S 3 AL
S 2 LP
S 3 LP
S 2 LP
S 2 LP
S 2 LP
S 3 AL
S 4 AL
S 2 LP
V
VI
VII
VIII
IX
X
XI
XII


TP. OF BLANDFORD-BLENHEIM
Eastwood
SALINA FORMATION
BASS ISLANDS FORMATION
BOIS BLANC FORMATION
BRANT CO.
OXFORD CO.
Muir
Vandecar
Kenny
TP. OF BURFORD
TP. OF NORWICH
Fur Farm
Oriel
Kilns
Orchard
Beaconsfield
New Durham
50
100
133
102
75
82
67
84
117
44
N


BOIS BLANC FORMATION
Burgessville
Big Creek
Orchard
126
130
Norwich
Norwich Gore
Otter Creek
Norwich Jct.
Sports Track
Poultry Farm
Fur Farm
154
DETROIT RIVER GROUP
AMHERSTBURG FORMATION
BIG CREEK
Milldale
Kilns
CANADIAN NATIONAL
TP. OF DELHI
OTTER
Otterville
DETROIT RIVER GROUP
LUCAS FORMATION
Springford
DUNDEE FORMATION
Abandoned
130
I
II
III
IV
VI
VII
VIII
IX


CREEK
Milldale
TP. OF DELHI
OTTER
Otterville
DETROIT RIVER GROUP
LUCAS FORMATION
Springford
DUNDEE FORMATION
109
Cornell
BIG
Summerville
Hawtrey
205
MICHIGAN CENTRAL
DUNDEE FORMATION
59
50
25
66
XI
XII
Kilns
FORMATION
TP. OF NORFOLK
OXFORD CO.
R.M. OF HALDIMAND-NORFOLK
VI
VII
VIII
IX
X

Ministry of Natural Resources
Ontario

Hon. Alan W. Pope
Minister

W.T. Foster
Deputy Minister

ONTARIO GEOLOGICAL SURVEY
AGGREGATE RESOURCES INVENTORY

TOWNSHIP OF NORWICH
OXFORD COUNTY

MAP 3
BEDROCK RESOURCES

Scale 1:50 000

Mile 1 0 1 Mile
Metres 1000 0 1 Kilometre

NTS Reference: 40 I/15 40 P/2

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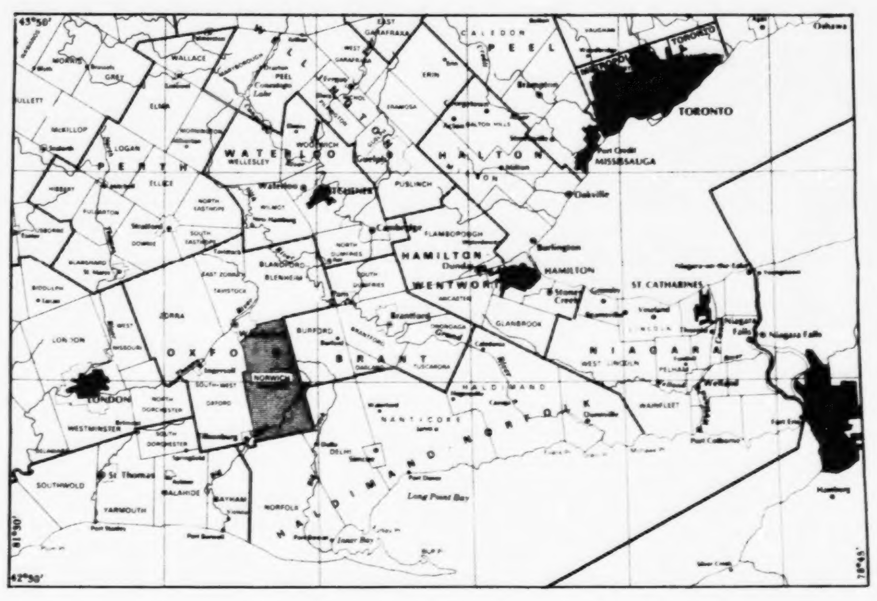
TORONTO
HAMILTON
ST. CATHARINES
OXFORD
BRANT
NIAGARA

LEGEND

PALEOZOIC
DEVONIAN
MIDDLE DEVONIAN
DUNDEE FORMATION
Limestone
DETROIT RIVER GROUP
LUCAS FORMATION
Limestone
AMHERSTBURG FORMATION
Limestone and dolostone

LUCAS FORMATION
Limestone
AMHERSTBURG FORMATION
Limestone and dolostone

LOWER DEVONIAN
BOIS BLANC FORMATION
Cherty limestone

SILURIAN
UPPER SILURIAN
BASS ISLANDS FORMATION
Dolostone
SALINA FORMATION
Dolostone, shale, gypsum, salt

SYMBOLS

(Some symbols may not apply to this map.)

— — — —	Geological formation boundary.
- - - - - - -	Geological formation member boundary.
—•——•—	Formation thickness boundary (see text).
——25——	Drift thickness contour: 25 foot (8 m) interval.
—— – ——	Municipal boundary.
▨ 2	Selected bedrock resource area; Deposit number: see Table 6.
■	Bedrock exposed or near surface; covered by less than 3 feet (1 m) of overburden: see Table 4.
▒	Bedrock covered by 3 to 25 feet (1 to 8 m) of overburden: see Table 4.
□	Bedrock covered by 25 to 50 feet (8 to 15 m) of overburden: see Table 4.
x	Isolated bedrock outcrop.
Q2	Licenced quarry boundary; Property number: see Table 5.
● Q3	Unlicenced quarry*; Property number: see Table 5. *Abandoned quarry or wayside quarry operating on demand under authority of a permit.
○ 28	Selected drilled waterwell location; reported depth to bedrock (in feet).

SOURCES OF INFORMATION

Base map by Surveys and Mapping Branch, Ontario Ministry of Natural Resources.
Licence data from District and Regional Offices, Ontario Ministry of Natural Resources.
Aggregate suitability data from the Engineering Materials Office, Ontario Ministry of Transportation and Communications.
Selected drilled water well data from the Ontario Ministry of the Environment.
Drilling data from the Petroleum Resources Section, Ontario Ministry of Natural Resources.

Geology by: P. J. Barnett and A.L. Starkoski, 1978.
B.V. Sanford, 1969.

x Isolated bedrock outcrop.
Q2 Licenced quarry boundary; Property number: see Table 5.
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Compilation and Drafting by: Staff of the Aggregate Assessment Office.

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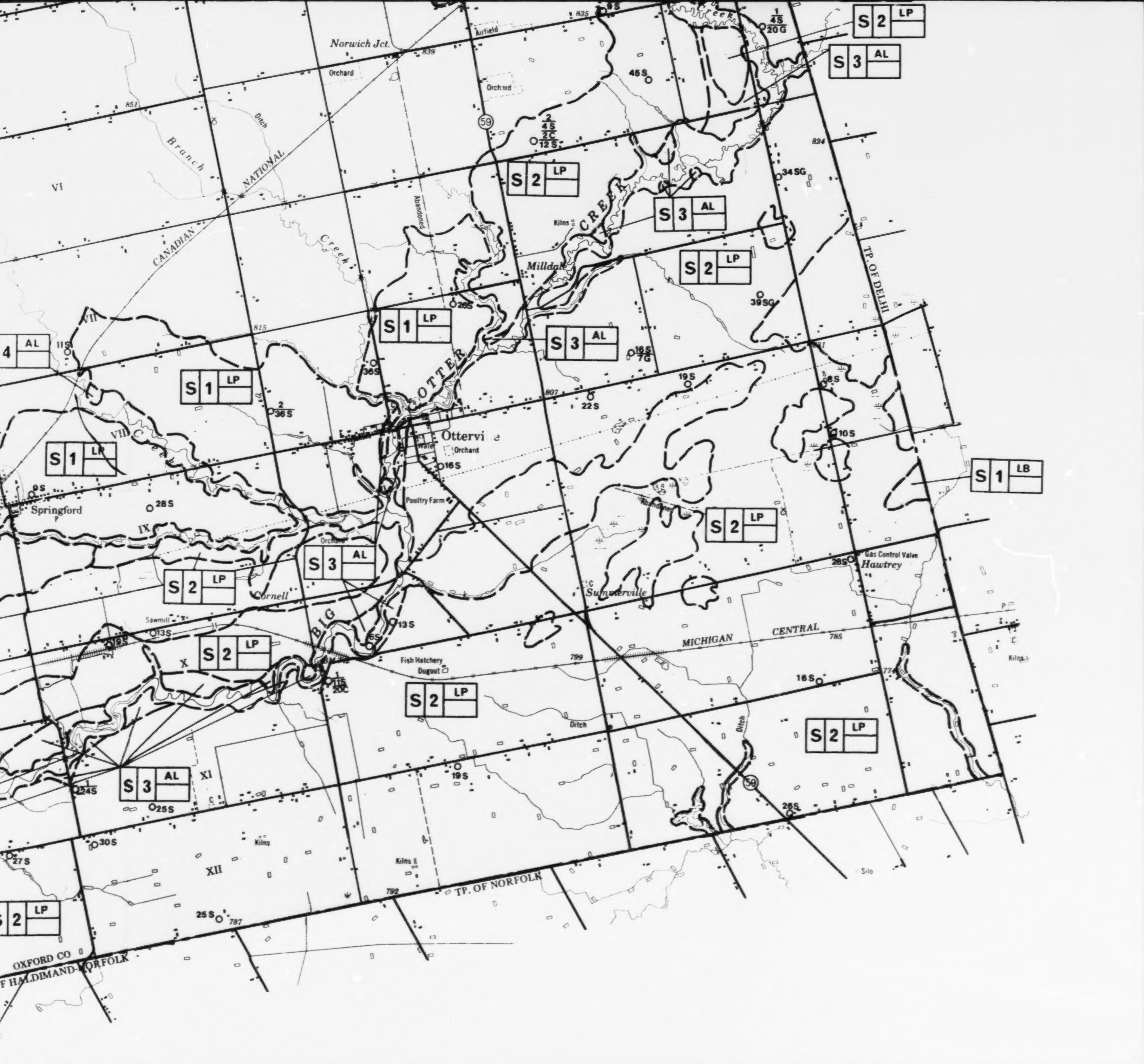
NORWICH


Norwich Jct.
Orchard
Airfield
Branch
CANADIAN NATIONAL
Ditch
Creek
CREEK
OTTER
BIG
Milldale
Kilns
Otterville
Poultry Farm
Springford
Cornell
Sawmill
Fish Hatchery
Dugout
Sumnerville
Gas Control Valve
Hawtrey
MICHIGAN CENTRAL
TP. OF DELHI
TP. OF NORFOLK
OXFORD CO
HALDIMAND-NORFOLK
VI
VII
VIII
IX
X
XI
XII
S 2 LP
S 3 AL
S 1 LP
S 1 LB
4 AL

Gravel Content

G	Greater than 35% gravel.
S	Less than 35% gravel.

Thickness Class

Class	Average Thickness in feet (metres)	Tons per acre (Tonnes per hectare)
1	greater than 20 (> 6)	greater than 50,000 (> 112 000)
2	10-20 (3-6)	25,000-50,000 (56 000 - 112 000)
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Geological Type

AL	Older Alluvium	**K**	Kame
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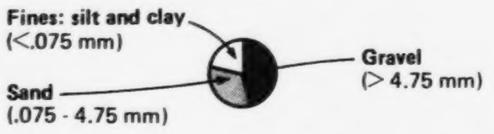
IC	Undifferentiated Ice-Contact Stratified Drift	**LP**	Lacustrine Plain
ICT	Ice-Contact Terrace	**OW**	Outwash
		WD	Windblown Forms

(see Appendix C for descriptions of Geological Types)

Quality Indicator

	If blank, no known limitations present.
C	Clay and/or silt (fines) present in objectionable quantities.
L	Deleterious lithologies present.
O	Oversize particles or fragments present in objectionable quantities

TEXTURE SYMBOL


Fines: silt and clay
(<.075 mm)
Sand
(.075 - 4.75 mm)
Gravel
(> 4.75 mm)

The Texture Symbol provides quantitative assessment of the grain size distribution at a sampled location. The relative amounts of gravel, sand, silt and clay in the sampled material are shown graphically by the subdivision of a circle into proportional segments. The above example shows a hypothetical sample consisting of 45% gravel, 35% sand and 20% silt and clay.

SOURCES OF INFORMATION

Base map by Surveys and Mapping Branch, Ontario Ministry of Natural Resources.

Licence data from District and Regional Offices, Ontario Ministry of Natural Resources.

Aggregate suitability data from the Engineering Materials Office, Ontario Ministry of Transportation and Communications.

Test hole data from Aggregate Assessment Office, Ontario Geological Survey, Ontario Ministry of Natural Resources.

Selected drilled water well data from the Ontario Ministry of the Environment.

Drilling data from the Petroleum Resources Section, Ontario Ministry of Natural Resources.

Geology by: P. J. Barnett, 1980.
W.R. Cowan, 1975.

Compilation and Drafting by: Staff of the Aggregate Assessment Office.

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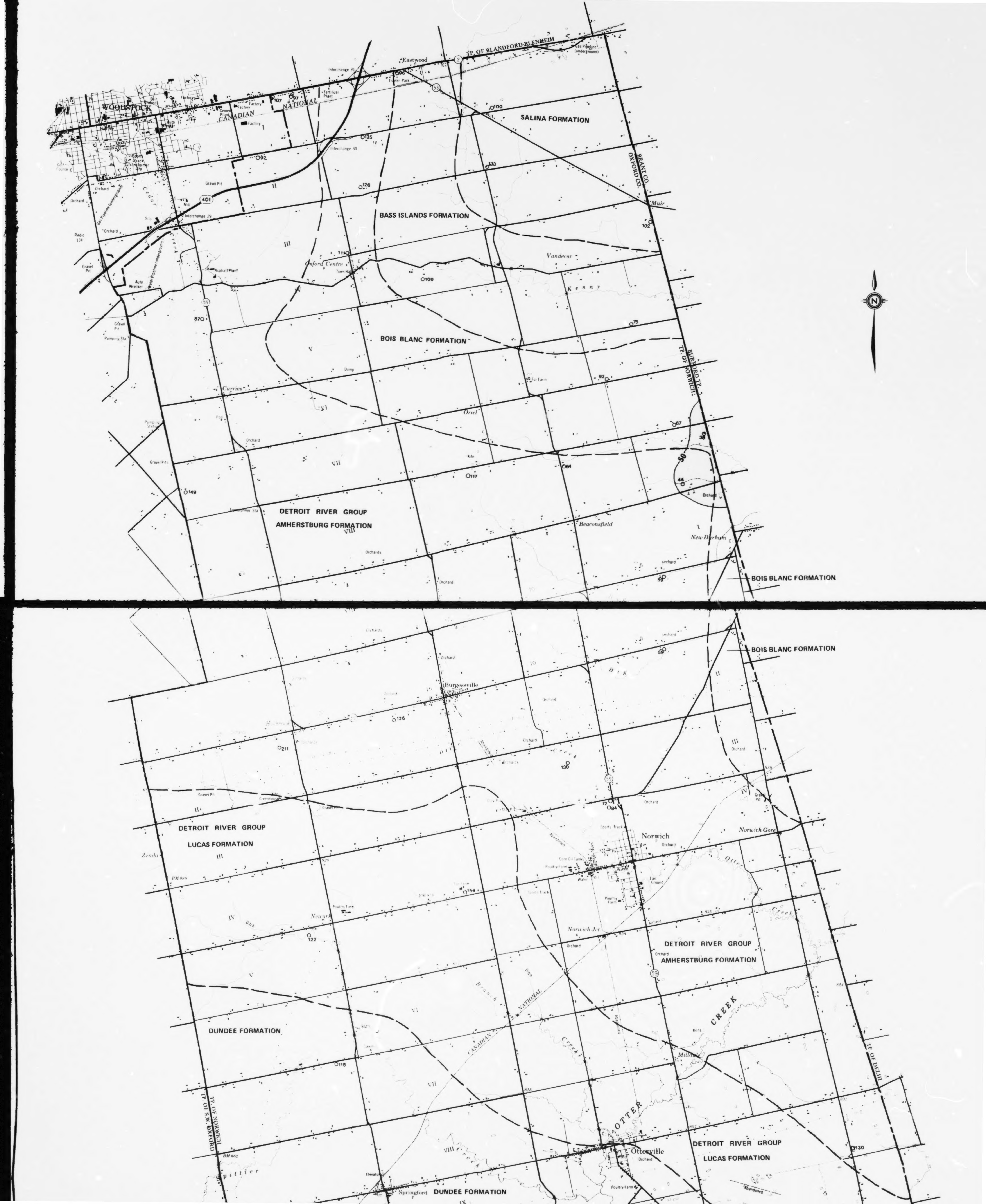
WOODSTOCK
CANADIAN NATIONAL
TP. OF BLANDFORD-BLENHEIM
Eastwood
Interchange 31
Interchange 30
Interchange 29
401
2
53
59
Trailer Park
Fertilizer Plant
Cement Plant
Factory
Gas Pipeline (underground)
Water Pipeline (underground)
Cedar Creek
Gravel Pit
Orchard
Radio 134
Auto Wrecker
Asphalt Plant
Pumping Sta
SALINA FORMATION
BASS ISLANDS FORMATION
BOIS BLANC FORMATION
DETROIT RIVER GROUP
AMHERSTBURG FORMATION
LUCAS FORMATION
DUNDEE FORMATION
BRANT CO.
OXFORD CO.
BURFORD TP.
TP. OF NORWICH
TP. OF S.W. OXFORD
TP. OF NORWICH
TP. OF DELHI
Muir
Vandecar
Kenny
Oxford Centre
Town Hall
Curries
Oriel
Fur Farm
Kiln
Transformer Sta
Beaconsfield
New Durham
Orchards
Burgessville
Big Otter Creek
Norwich
Norwich Gore
Norwich Jct
Sports Track
Fair Ground
Poultry Farm
Newark
Zenda
Greenhouse
CANADIAN NATIONAL
Abandoned
Otter Creek
OTTER CREEK
Milldale
Otterville
Springford
Elevator
Pittler
BM 862
BM 988
I
II
III
IV
V
VI
VII
VIII
IX
100
92
107
97
96
135
133
126
102
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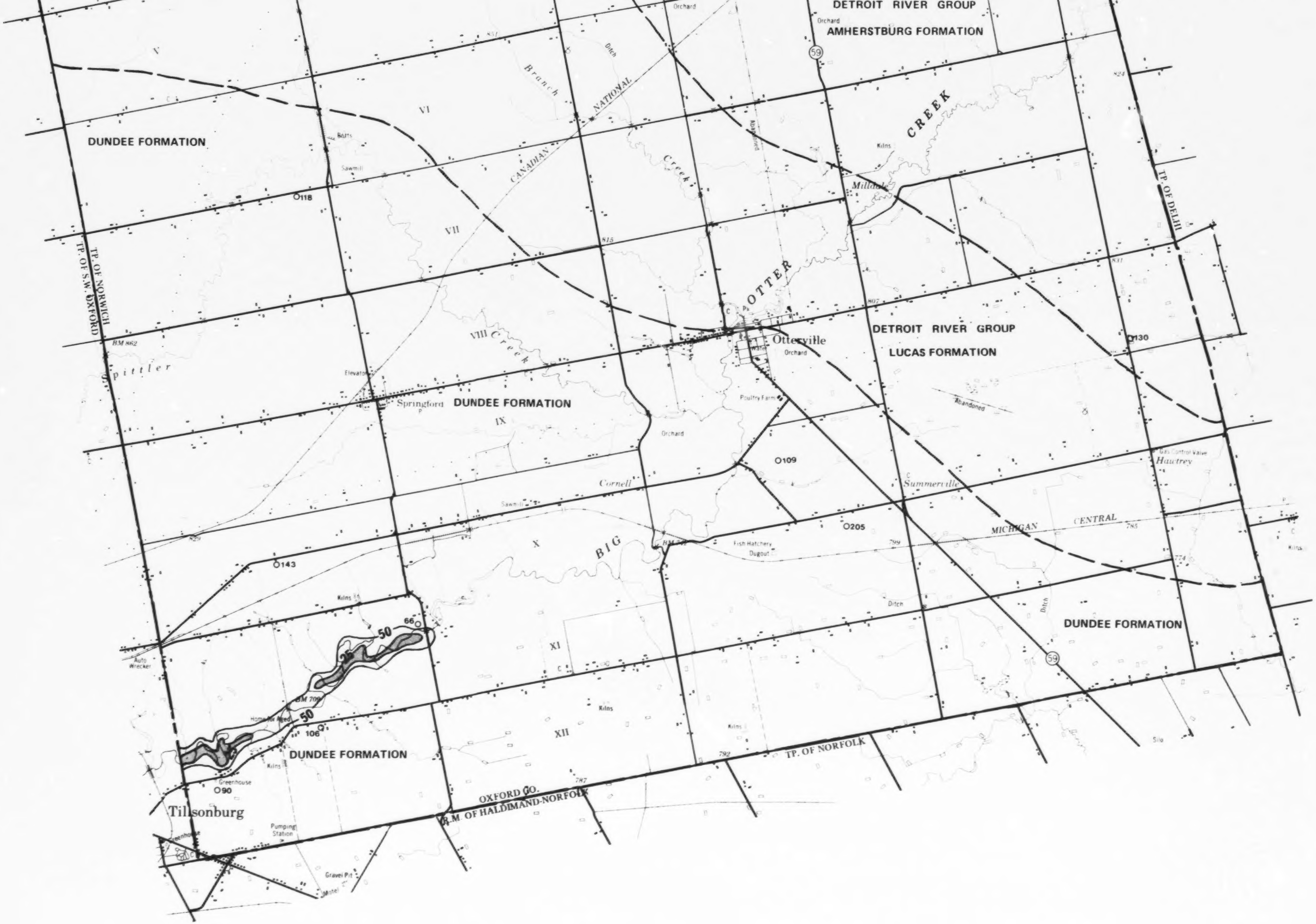
72
84
154
122
118
130



DETROIT RIVER GROUP
AMHERSTBURG FORMATION
DUNDEE FORMATION
DETROIT RIVER GROUP
LUCAS FORMATION
DUNDEE FORMATION
DUNDEE FORMATION
DUNDEE FORMATION
OTTER
CREEK
BIG
Creek
Creek
Branch
Ditch
Spittler
CANADIAN NATIONAL
MICHIGAN CENTRAL
Otterville
Springford
Tillsonburg
Milldale
Summerville
Hawtrey
Cornell
Bolts
Sawmill
Elevator
Orchard
Poultry Farms
Fish Hatchery
Dugout
Kilns
Greenhouse
Home for Aged
Pumping Station
Gravel Pit
Motel
Auto Wrecker
Gas Control Valve
Abandoned
Silo
V
VI
VII
VIII
IX
X
XI
XII
118
143
109
205
130
106
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BM 862
BM 709
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807
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785
774
792
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TP. OF NORWICH
TP. OF S.W. OXFORD
TP. OF DELHI
TP. OF NORFOLK
OXFORD CO.
R.M. OF HALDIMAND-NORFOLK